SURFACE TREATMENT OF MACADAM AND GRAVEL ROADS

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(Editor's Note: The following is from a paper read before the 1926 meeting of the American Road Builders' Association.)

There should be no more interesting subject to discuss than surface treatment. If it could have been made an interesting subject 15, or even 10, years ago, many millions of dollars would have been saved to the taxpayers and there would be many more hundreds of miles of good travelable road in America today than there is. It seems a little short of a calamity that a subject as important as this should have been neglected to the degree it has been.

One of the greatest blunders which the highway official has made in the administration of the highway affairs by and large, is letting the public think of types of construction rather than of the road as a means of transportation. The public is in fact not at all interested in whether it rides from New York to Washington over a sheet asphalt pavement, over a concrete pavement, over a penetration or over a water-bound macadam road. What it is interested in is riding over a road maintained in good serviceable condition every day in the year. If we can train the public mind to demand good roads, but not to demand good roads of a type, we will be doing them a great favor, and we will be putting the road building of the nation on a scientific basis on which it deserves to be. There is not a single governmental or semi-governmental agency which has contributed more to the happiness and prosperity of the nation than good roads and there is no agency as likely to contribute more in the next generation.

Fallacies of the Past

Ten years ago, for instance, it was the belief of the maintenance engineer that the important part of his annual work was the surface treatment of every mile of macadam road. An application consisted of somewhere between ¼ and ½ gallon to the square yard. It was applied to the surface in warm or cold weather, but it was applied when it was convenient for the highway department to apply it without any regard to whether the road needed it or was in condition to receive it. It was in this period that many roads were destroyed from too much surface treatment, but the greatest real losses came from the fact that in this period the public became utterly disgusted with surface treated macadam roads. It is no wonder that they became disgusted because always a sufficient amount was applied to cover the surface of the road, to form great pools along the edges which stood there for days, enough to cover the fenders, windshields, bodies and tops of automobiles that passed over it, and the clothing of all the occupants of these automobiles. Those who were familiar with surface treatment conditions in those days know that the public was perfectly justified in becoming intolerant of this situation, and since some road was treated almost every day from the early spring until late fall, some part of the system was under surface treatment during this period, and it was impossible for a motorist to go a hundred miles in any direction in the summer without encountering what he considered the greatest of all nuisances connected with motoring.

Since the net result of this loss of patience of the public with surface treatment has been a loss to them of millions of dollars every year in the scrapping of good roads of a type which required surface treatment and the substituting for them of a type which did not require it, this result is still being felt today because it contributed so largely to the inability of the states to keep their highway program anything like apace with the demand from the automobile.

To say that many, many miles of good macadam roads have been permitted to go to pieces either from lack of surface treatment or from an excess of surface treatment is a simple statement of facts; that many of these miles of road could have been saved and could have been in use today is my firm belief.

The surface treatment of macadam and of gravel roads will be discussed separately because entirely different materials and methods are employed in each of them.

Macadam Road Treatment

It is very easy to generalize about the surface treatment or lack of surface treatment of roads, and it is very easy now to state specifically how surface treatment can be successfully done and to state specifications for materials which will give very satisfactory results, but the difficult and really essential

thing about surface treatments is to know when it is to be done. I regret that I can not give a very definite formula for *when* roads are in need of surface treatment, but if I can direct the maintenance engineers' attention to the fact that the most important feature with the maintenance of any surface treated macadam road is *when* and not *how* it is to be surface treated, I am sure he can determine for himself when roads are in need of this treatment. The nearest safe rule I can give is to put off surface treatment work as long as it is possible to put it off and then wait another year before actually applying it. This rule may at times cause considerable patching before another year rolls around, but the probabilities are that the patching will not be more than mildly troublesome and slightly expensive, and additional surface treatment before one is needed will invariably bring about the destruction of the road through the creation of transverse waves which will make the road unsatisfactory, if not impossible, of use.

The road ideally maintained under surface treatment is one which has a continuous film of bituminous material, impervious to water, over the entire surface of the road and of no appreciable thickness. One application to a new road will form a mat which will give some wear. A second application the second year will add something to the depth of the mat and something to its uniformity. An application for the third and fourth year will invariably destroy the road by the building up of a mat of excessive thickness which will set up transverse waves, for which there is no remedy except to completely remove them. This, in most cases, means completely scarifying and resurfacing the entire section of the road. On the other hand, the allowance of too much time between successive treatments will permit the surface of the road to disintegrate and it may be destroyed from this cause. It has been my observation, however, that many more roads have been destroyed from too much treatment than from too little.

The time for the determination of whether a road requires surface treatment or not is in the late fall or in the early spring. During the winter most roads will appear to need a surface treatment during the next year, which condition is often corrected in the spring when the bituminous material begins to get back its life. In examination for the need of surface treatment it is necessary to take into consideration the percentage of dry places which appear in the surface. A place here and there which needs surface treatment does not necessarily indicate that the road needs it. I would say as a general thing that unless surface disintegration shows on an area equal to 5 per cent of the total area of the surface, that it is not in need of an additional application.

When it has been determined that a macadam road previously treated is in need of surface treatment, tars or asphalts conforming to the following specifications will give very satisfactory results if applied with reasonable care. For a road which is being treated for the first time, we have found much more satisfactory results are obtained from the use of the tars than of the asphalts, but after the initial application either gives equally satisfactory results.

The time of the year plays as important a part in the surface treatment of roads as does the material itself, or the rate of application. We know that the rate of application is tremendously important, yet what we assume in the rate of application is a uniform amount for each and every square yard. During the hot summer months, it is, of course, possible to spray an equal amount on the road but it is impossible to keep it there. Though as little as ¼ or even 1/5 gal. to the square yard is used in excessively hot weather, we have found that a considerable amount of this will work toward the edges, leaving too little in the center and too much along the edges, so that all efforts to bring about uniform distribution are destroyed by gravity displacing the material on the surface. For the convenience of the traveling public we determined that all surface treatment work should be completed before the first day of July. In our efforts to please the public, we discovered that we were able to at the same time eliminate one of the greatest causes of dissatisfaction to the engineer himself on the application of surface treatment.

We were able by doing the work in moderately cool weather to have whatever material was placed on the surface remain where it was placed. This is essential to any successful surface treatment. I would say that a rule, which should be inflexible, is that no roads are

to be surface treated between the first day of July and the first day of October. It is true that occasionally excessively warm spells are encountered in Maryland in June and this is true of other localities, but it is not often that these will be found, and when they are encountered, surface treatment should be discontinued. On an average, all of the weather in the summer months is too warm for successful surface treatment work. The surface of the road must be sufficiently cool when the material is applied to it to prevent running or creeping on the surface.

Surface treating material which is sufficiently heavy to remain in place when applied and of the specifications recommended will require heating to enable it to be pumped from a tank car, and in addition, on many days will require that heaters be placed under the distributors. It is essential, therefore, that all pressure distributors be equipped with heating apparatus in addition to having the tank car equipped with coils for heating purposes.

We will assume a fair day's work to be 5,000 gals. of material applied at the rate of ¼ gal. to the square yard, which will cover a little more than two miles of road of a width of 16 ft. The number of men to do the covering and the length of haul for the truck will increase in advance of the gang doing the covering, and the public should, at all hazards, be kept from using any part of the road which has been treated and which has not been covered, not because of any great damage which may occur to the road, but because of the very great danger of accident should a motor vehicle try to stop on a part on which the material has been spread and not covered. If the bituminous material is covered and thoroughly rolled, within two hours travel may safely go over it. Any time after this the second side may be treated. The bituminous materials, especially the asphalts, seem to cut back previous surface treatments, so that there is apt to be some movement of the cover material for a period of about 48 hours.

Gravel Road Treatment

The surface treatment of gravel roads is a problem on which most of the experimental work of which I know has been done by Mr. Paul Sargent of Maine. The material which we have adopted and found most excellent in every respect was developed by him and our method of application and treatment was obtained from him, and I take this opportunity to express my appreciation for what he has done for the surface treatment of gravel roads and congratulate him upon the results. The material which we have used conforms to the following specifications:

Tars only will be used for the surface treatment of gravel roads and the material shall be homogeneous and meet the following requirements:

1.	Specific gravity 25 deg. Cent. (77 deg. Fah.)	not less than 1.100
2.	Specific viscosity at 40 deg. Cent. (104 deg. Fah.)	8 to 13
3.	Total distillate by weight—	
	To 170 deg. Cent. (338 deg. Fah.)	not more than 5 per cent
	To 270 deg. Cent. (518 deg. Fah.)	not more than 32 per cent
	To 300 deg. Cent. (572 deg. Fah.)	not more than 42 per cent
4.	Total bitumen (soluble in carbon disulphide	not less than 90 per cent

Tests of the physical and chemical properties of the tar shall be made in accordance with the following methods:

1. Specific gravity, Department of Agriculture, Bulletin 314, p. 4.
2. Specific viscosity (on first 50 c.c.) U. S. Department of Agriculture Bulletin 314, p. 7.
3. Distillation test, A. S. T. M. Standard Test D20-16.
4. Total bitumen (soluble in carbon disulphide), not less than 90 per cent.

or diminish this amount, but we have found this to be a fair day's work for one outfit. Prior to the application of the bituminous material, stone chips of a good hard quality or clean washed gravel, in either case passing a 1-in. ring, free from dust, should be provided along the side of the road at the rate of 20 lbs. per square yard.

The material should be applied to one side of the road at a time. It should never be applied an appreciable distance

We have had to adjust the use of this material to local conditions and the results obtained have been highly satisfactory. Under the methods we have used we are obtaining from gravel roads a type of surface which closely resembles macadam, and which in every respect seems to indicate that it will give most satisfactory results for comparatively light traffic.

The gravel roads in Maryland are composed of either screened or pit run gravel containing 60 per cent of material larger

ASPHALT SPECIFICATIONS

The materials to be used shall be prepared by fluxing an asphalt cement of 120 to 150 penetration (100 gr., 5 sec., at 25 deg. Cent.) with naphtha. The naphtha used when distilled in accordance with the A. S. T. M. method D 86-21 T. shall have an overpoint of not greater than 225 deg. and the drypoint should not exceed 450 deg. The naphtha shall show a continuous distillation between these points.

The prepared oil shall conform to the following specifications, shall be homogeneous, free from water and conform to the following analyses:

	Min.	Max.
Specific gravity at 25 deg. Cent.	0.93	...
Flash point, open cup, deg. Cent.	...	65
Evaporation loss, 20 g. 5 hr., 212 deg. Fah. (100 deg. Cent.) per cent by weight	22	...
Evaporation loss, 20 g. 5 hr., 325 deg. Fah. (163 deg. Cent.) per cent by weight	27	...
Consistency of residue after evaporation—		
Penetration at 25 deg. Cent. of residue of 20 gr., 325 deg. Fah. loss	...	100
Specific viscosity (Engler) first 50 c.c. at 40 deg. Cent.	40	60
Insoluble in 86 deg. Naphtha, per cent	14	...
100 Pen. asphaltic content (open evaporation at temperature not to exceed 500 deg. Fah.), per cent	68	...

than ¼ in., the filler being composed of an intimate mixture of sand clay. These roads under the light traffic for which they were constructed give, we believe, the most satisfactory results of any roads in Maryland. However, where the traffic exceeded about 300 vehicles per day, the dust became very objectionable. The corrugations appeared much more quickly under the heavy traffic and there was considerably more breaking down of the surface, but on the whole, the dust situation became so acute as to be intolerable. Some of these roads on Sunday are carrying as many as 5,000 pleasure vehicles per 24-hour day. There is, however, almost a total absence of trucks in excess of 3-ton capacity. Because of the nature of the country through which they run, there is reason to believe that there will not for many years be an appreciable amount of heavy trucks go over these roads.

One application of this material gave no satisfactory results even for the first season. It was necessary in all cases to give two applications in one season, which gave a surface that satisfactorily carried over the winter, and with an additional treatment the second year appeared to be in a position to give at least two, if not three, years of service without an additional application.

It is self-evident, of course, that the road after surface treatment can be no smoother or more uniform in cross section than the road before treatment. Needless to say, only a gravel road in very good condition should ever be surface treated. All weak spots could be discovered and completely removed and replaced with good material at least a month in advance of the first oiling and the road should be kept dragged and graded to a good, uniform condition, free from corrugations and weak spots. A gravel road should be oiled only when dry. It is, of course, much more difficult to get an untreated gravel road dry than it is to get a previously surface treated macadam or gravel road dry. However, it is essential that the surface be dry before the material is applied to it.

A rotary broom is used, supplemented by hand brooms where necessary to re-

TAR SPECIFICATIONS

The materials to be used under these specifications shall be homogeneous, contain not more than 2 per cent of water and conform to the following analysis:

Coal Gas—	Min.	Max.
Specific gravity at 60 deg. Fah.	1.15	1.19
Viscosity (Engler), (first 50 c.c. at 40 deg. Cent.), inches	250	350
Insoluble in carbon bisulphide, per cent	6	12
Distillation (250 c.c.) (Engler Flask):		
Up to 170 deg. Cent., per cent	...	7
Up to 235 deg. Cent., per cent	...	18
Up to 270 deg. Cent., per cent	...	35
Up to 300 deg. Cent., per cent	...	43
Water Gas—		
Specific gravity at 250 deg. Cent.	1.10	1.14
Viscosity (first 50 c.c. at 40 deg. Cent.), inches	250	350
Insoluble in carbon bisulphide, per cent	...	4
Distillation (250 c.c.) (Engler Flask):		
Up to 170 deg. Cent., per cent	...	2
Up to 235 deg. Cent., per cent	3	15
Up to 270 deg. Cent., per cent	18	30
Up to 300 deg. Cent., per cent	25	40
Melting point res. (Ring and Ball method)	30	60

move from the surface all of the loose material so that the bituminous material may better penetrate into the surface. The first application should be at the rate of ½ gal. per square yard, applied uniformly with a pressure distributor. This application should be immediately covered with the material which is swept off of the road, provided, of course, it is not clay, but is a combination of sand and gravel. This would usually be the case on roads under travel because the action of the vehicles over the road will blow away most of the clay. Such of the covering material as has been carried off by traffic during the first day should be applied again the second day. Special care should be used to cover every spot which appears to be bleeding. These spots should again be covered for the second and third day.

A traffic of 300 or 400 vehicles per day is usually sufficient to work the cover material into the tar, but if it is not, it may be supplemented by rollers. A small roller of four or five tons seems to give equally as satisfactory results as the larger 10-ton rollers. After this first application about a month should elapse, during which the bituminous material will "cure" and before the road is ready for a second application. Any weak spots which appear during this period should be immediately patched with a mixture of gravel and bituminous material. For this we have used a standard cold patch material used in Maryland for all types of macadam patching.

For the second application, better material is required for covering than for the first application. Coarse sand, or a combination of sand and gravel consisting of gravel no larger than ¼-in. should be used. The material should be entirely free from clay. Before the second application, a scraper and hand broom should be used to remove the loose material and foreign substances which might be on the surface. This application should be at the rate of ¼ gal. to the square yard spread uniformly and immediately covered with a combination of sand and fine gravel. This material should be kept spread back on the surface as fast as it is pushed off by travel for a period of at least four days after this application.

One of the really essential things about surface treatment of gravel roads is to keep applied to the surface an excess of covering material at all times so that the maximum amount may be worked into the surface during the "curing" period. If this material is allowed to be kicked off by vehicles and to lie along the edge of the traveled way, it will absorb a considerable amount of the tar which has been applied to the surface and this will eventually dry out and be of no value. If there is not sufficient traffic and if it is not sufficiently diversified to cover the entire surface, the road should be rolled with a power roller for the first three or four days after application. Where there are as many as 500 vehicles per 24-hour day, there will generally be no need of rolling to work the covering material into the tar surface.

The roads in Maryland treated by this method are not more than two years old, but the results obtained after last winter and so far during this winter indicate most satisfactory results. The roads which had but one application during 1924 showed a marked disintegration during the spring of 1925, so much so as to lead definitely to the conclusion that one treatment is not satisfactory for the type of gravel roads found in Maryland. Certainly, if those roads with two applications can the first year be made to give service approaching that of macadam roads without the need of scarifying, rebuilding and retreating in the spring, it will prove much more satisfactory than the one application treatment, which will require scarifying, rebuilding and retreating the next year.

MAINTENANCE OF GRAVEL ROADS IN WISCONSIN

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(Editor's Note: The following is from Bulletin No. 16, recently issued by the Wisconsin Highway System. The Bulletin discusses in great detail, with many illustrations, the methods used in maintaining the Wisconsin State Trunk Highway System).

Gravel is the most abundant road surfacing material to be found in Wisconsin and as a consequence, there are more miles of road surfaced with gravel than with all other types combined. This type of surfacing must take care of traffic on many of our main highways until a more suitable surface may be built, and in many cases it will be the main surfacing for several years to come.

Classification

Gravel roads in Wisconsin might be divided into two classes, namely, those roads which have been built according to specifications with proper depth and width and proper gradation of materials, and those which have been built through maintenance operations in several light layers. The latter class usually is not of full depth and may be called light surfacing. It will take care of moderate traffic while the first class mentioned will take care of fairly heavy traffic very adequately.

Pit Run Gravels

In the early days of highway construction a good many gravel roads were built of material taken just as it occurred in the pit, but experience has shown that it is almost impossible for a patrolman to keep a uniform cross section with pit run gravel or to maintain this type of surfacing economically. During the past four or five years practically all of the old pit run gravel roads have been rebuilt by scarifying and resufacing.

Standard Specifications

The Wisconsin specifications now require that all materials in one course gravel roads must pass through a 1-in. round opening. This provides a material that may be readily graded or planed by the patrolman. Where a two course road is built, the bottom course shall consist of a mixture of gravel, sand and clay, all of which must pass a 2-in. screen, the top course to consist of the same material as used in the one course road. The one course road is usually built on the lighter soils whereas the two course road is more satisfactory where heavy soils are encountered.

Construction Features

In order to properly maintain a gravel road, the patrolman must have a working knowledge of the construction features as proper maintenance really consists of building up or adding materials from time to time. Practically all gravel roads built today have the maximum depth at center and are feathered at the edges, and the surfacing is spread in many cases over the entire width of the roadbed. This provides a wide space for traffic to use and the concentration is, therefore, minimized, resulting in more economical maintenance.

Placing, Mixing, Grading

Before applying gravel, the subgrade must be graded to a flat cross section, and in many cases it is advisable to have it slightly concave. The surfacing should then be placed, preferably in thin layers or not to exceed 4 or 5 ins. Where it is dumped on the subgrade in loads, it should be employed to constantly move the material from one side of the road to the other, thus making a uniform surface. The most important period in the construction of a gravel road is during the actual depositing of the material and the time during which the gravel is "setting-up" or compacting. A uniform surface is dependent on the care and attention given the material during construction and immediately thereafter. In very few cases are gravel roads closed to traffic during construction. This permits traffic to assist in compacting the surface. Very seldom is a roller used on a gravel road. Where the deposit contains very little clay binder, it is necessary to add clay at the time of depositing the material on the subgrade. The clay is mixed with the gravel by a blade grader or a similar device. Some deposits have an overabundance of binder and in that event it must be screened out in order to get a satisfactory surfacing material. The maintenance of gravel roads like all other types should begin the moment the material is placed on the subgrade. Patrol maintenance alone will not be sufficient. It is very necessary on many of the roads to use gang crews in resurfacing and widening, etc. The following rules will apply to practically all gravel roads:

Important Factors

1. Be sure that the road goes into winter in the best of condition. Ditches and culverts must be free and open. The surface must be smooth and free from holes and depressions, and it should have sufficient crown to take care of surface waters. In fact, during the fall season a gravel road should have slightly more crown than during the summer months. Have just enough crown to shed the water and no more. Experience has shown that 4 ins. in 24 ft. is sufficient. To the casual observer this would appear practically flat.

2. The entire road should be graded with a large grading outfit, moving the surface material from one side to the other, cutting down the high spots and filling the depressions, thus giving the patrolman a good surface to start with in the spring.

3. Add new material at all places where the original surface has broken through under heavy traffic or by spring

frost conditions. In order to keep up the original depth, a light coat of material should be applied over the entire road.

4. Keep a mulch of fine gravel about one-half to one inch in depth over the surface at all times, and move this from side to side with the grader in the regular maintenance operations.

Surface Treatments

The ordinary gravel surface will be economical and serve adequately for light traffic, but when traffic reaches an average of 300 or more vehicles per day, some form of surface treatment is necessary to (1) preserve the original investment by conserving the material, (2) to provide for safety by eliminating the dust nuisance, and (3) to increase the efficiency of the highway.

Up to this amount of traffic there is probably no question but what the addition of material from time to time will keep the road in very good condition at a lower cost per mile per year than by any form of surface treatment. However, an important factor to keep in mind is the annual loss of material on the many miles of gravel road. This loss cannot go on indefinitely without seriously hampering the economy of gravel road construction. The most common palliatives used thus far by the various states are: Calcium Chloride,—Light asphaltic road oils,—Light tars and Medium asphalts.

Calcium Chloride Treatment

Method.—Calcium chloride has been used quite extensively throughout this state and more so in some of the neighboring states in combatting the dust nuisance. This type of treatment is quite satisfactory, but it requires the regular patrol operations to keep the surface smoothed up at all times and requires at least two treatments per season. Calcium chloride should not be used on gravel surfaces having a large clay content as the moisture drawn from the air would tend to make the surface slippery and would have the same effect as a shower of rain. Before treating the road, it should be properly shaped to a uniform cross section and then the first application of about three-fourths to one pound of calcium chloride per square yard should be placed with an ordinary lime sower or similar device. This treatment should be followed with a second treatment of about the same quantity per square yard from a month to six weeks later. If the season should be an unusually dry one, a third application may be found necessary. Experience shows that approximately two pounds per square yard per season work out very satisfactorily on the average gravel road. Some prefer two applications where others believe three, using smaller quantities for each application, are more satisfactory. That is a problem that should be worked out for each individual case.

Costs.—Considering the above as an average, the cost per season for materials and labor in applying the treatment would vary from 3 to 5 cts. per sq. yd. The time and expense of the patrolman in daily patrolling the surface should be included. This would add approximately $150 to $200 per mile per year, making a total cost per mile of between $400 and $600 depending upon the width treated. The calcium chloride treatment does very well in keeping down the dust and holding the material on the surface, but it must be repeated annually as it has no permanent effect.

Light Asphaltic Road Oils

Method.—Light asphaltic road oils have been used to some extent on gravel roads but to a larger extent on dirt roads. It may be said that this type of treatment will also keep the dust down and provide a satisfactory riding surface for a limited time. The oil also waterproofs the surface to the extent that it will shed water very rapidly during rainy spells. One disadvantage in this type of treatment is that the surface will gradually become smooth and shiny in spots and, as the oil evaporates, it will start to disintegrate and thus cause a very rough and uneven riding surface. This may be eliminated to a certain extent by keeping a light mulch of fine material on the surface at all times, and grading it from one side to the other, thus prevening a crust from forming. Usually about one-half gallon of oil per square yard will suffice on the average gravel road, although it often becomes necessary to make a light second application later in the season to preserve the original smooth surface.

Cost.—The light oil surface treatment will cost approximately $350 per mile per year, plus the patrol maintenance cost which will bring the total per season between $500 and 600, or about 4½ to 6 cts. per sq. yd. Treatments the following year will require less oil per square yard and thus the cost the second year will be decreased slightly. The road should be scarified annually and it is very necessary that these treatments be followed

up from year to year if a uniform surface is to be maintained. If this is not done, the surface will soon disintegrate and become very rough.

Light Tar Treatments

Methods.—More miles of gravel road have been treated with light tars than with any dust palliative except calcium chloride. In general there have been three methods employed; (1) that which provides a skin treatment where the penetration is less than 1 in.; (2) a treatment where a penertation of approximately 1½ to 2 ins. is attained by mechanically mixing the tar and surface gravel with a grader and allowing traffic to compact the material; (3) where the surface materials are mechanically mixed the same as in case two, and a light roller is used to compact the treated portion. The first named treatment has been used a good deal in several states with considerable success but that type of treatment requires annual scarifying, reshaping and retreatment. The surface will not usually go through the winter season without being broken up by winter traffic and therefore requires scarifying each spring.

The Skin Treatment

The skin treatment may be briefly outlined as follows:

Method.—The road to be treated is brought to uniform cross section and excess loose material is removed from the surface by a power sweeper. After the sweeping operations are completed, the surface of exposed metal should present a mosaic appearance. An application of about one-sixth of a gallon per square yard is then applied with a power distributor. Tar may be heated not to exceed 125°F. to facilitate distribution and penetration. This is allowed to penetrate for at least 48 hours. No absorbent is used after the first application of tar. If traffic cannot be conveniently shut off it is allowed to move over the road. The second application of about one-third gallon per square yard is applied from two days to a week later, this application being immediately followed with coarse sand or pea gravel. If the tar shows a tendency to bleed, more sand should be applied. Within a few days, traffic will gradually iron out this surface making it appear very much like a bituminous macadam or an asphalt surface. The penetration, however, is from ½ to ¾-in. Any holes that may appear in the surface are patched from time to time by material consisting of a mixture of 17 gals. of light tar mixed with 1 cu. yd. of coarse sand. This treatment has been used quite extensively in the states of Maine, New Hampshire and other eastern states with considerable success but it has been found necessary to scarify and retreat each year. The annual cost will vary from 8c to 11c per sq. yd. for the first year. Subsequent treatments will decrease slightly in cost due to the fact that less tar is required in succeeding years.

Wisconsin Special Mixing Method (Traffic Bound)

Method.—This method was especially devised to do away with the annual scarifying and retreatment operations and it is especially adapted to gravel roads having an inch or two of loose material on the surface. Under this method the road is brought to uniform cross section and it is quite desirable to have some loose material on the surface. An application of about 1/4 to 1/3 gal. per sq. yd. is then placed on the entire surface. The amount of tar will depend somewhat on the porosity and the absorbent power of the surface materials. Immediately following the first treatment, a large blade grader with blade set at an angle of approximately 45 degrees and at a depth of ¾ to 1 in. moves the material a few feet beyond the center of the road. The distributor immediately follows the large grader with an additional 1/4 to 1/3 gal. per sq. yd. The material previously moved to the center of the road is then moved back over the freshly applied tar. The same operation is followed for the other half of the road and in order to get a thorough mixture of the tar and surface gravel the entire surface should be moved back and forth several times with the grader. After traffic has been allowed to use the road for a week or ten days, the necessity of a light seal coat may be easily determined. Ususally the movement of traffic over the road irons out the surface to such an extent that some of the tar works up to the top and sufficiently seals the surface so that an additional treatment is not necessary. However, if it is found that the tar does not readily work to the surface a light seal coat followed with an absorbent of coarse sand or pea gravel is advisable. Extreme care should be exercised not to use too much tar, for if there is too much binder present the surface is apt to shove or wrinkle. With this method it has been found that a crust or mat of 1½ to 2 ins. in thickness is built up. The amount of tar required varies from 2/3 to 3/4 gal.

per sq. yd. and the cost varies from 9c to 14c. While experimental pieces of road, treated with this method have only been in service for two or three years, it is safe to say that under this treatment a reasonably smooth surface may be maintained for several years with but a light application every two or three years.

Cost.—The original cost per mile on an 18-ft. width is from $900 to $1,200 per mile. The succeeding years the cost will depend on the amount of patching necessary and this is usually very small if the original treatment was properly placed so that over a four or five year period the average cost per mile is cut down to approximately $600 or $700. It is unnecessary to scarify this surface each year as is the case with the skin treatment outlined above.

Advantages.—The one emphatic complaint that motorists have against oiling or tarring of any description is that their cars get spattered with oil or bitumen and this causes them extra expense and inconvenience. By treating a road under the mixing method this objection is practically eliminated, as traffic is allowed to use one-half of the road while the other half is being treated. Experience has also shown that by immediately mixing the bitumen with gravel that the resultant mixture is not readily picked up by the moving vehicle but on the contrary traffic tends to compact the surface.

The Mixing and Rolling Method

This method is the same as the mixing method except that instead of allowing traffic to iron out the surface, a light roller of not more than five tons in weight is used to compact the material. The advantage in this method is that the surface is smoothed by rolling the entire width immediately after the mixing has taken place and traffic will not be inclined to follow the same rut. In other words, it will be distributed evenly over the entire surface whereas in the traffic bound mixing methods vehicles are inclined to follow the ruts of the vehicle that preceded. The cost of the mixing and rolling method is practically the same as the preceding method.

Medium Asphalt

Method.—Treatment with this material is somewhat different than with light tars. Usually it is applied in two applications about six weeks apart. After the first application a planer or drag is used constantly over the surface at the same time allowing traffic to iron it out. The second application is placed about six weeks later and is followed with a covering of coarse sand. While there have been but a few miles of gravel roads treated by this method in Wisconsin, it is believed that satisfactory results may be obtained with medium asphalt.

Value of Surface Treatments.—Surface treatments render a definite service to the road user as well as to the one who lives along the highways. The expenditures can be easily justified where traffic is heavy enough to warrant the treatment. This is especially true when you consider that on the average plain gravel road which has a traffic of 500 or more vehicles per day that the annual loss in material on an 18-ft. width is from 300 to 400 cu. yds. per mile. Figuring this at $2 per cu. yd. in place we would have $600 to $800 per mile loss in material each year if it is not surface treated. No community is so well supplied with materials that they can afford to lose this amount each year indefinitely. Even if the road will eventually be paved with a durable pavement, materials must be conserved for the secondary and local roads. In addition to making the saving in material there is elimination of the dust nuisance which has been responsible (1) for many of the highway accidents and unsanitary conditions, (2) for deterioration of motor equipment, clothing, buildings, furnishings and farm crops, and (3) for decrease in efficiency of the highway. When you consider what this means on the many thousands of miles of gravel roads on the various state systems it is obvious that a surface treatment renders not only a true highway service but it is a sound business proposition. It does not take the place of a durable pavement but it bridges the gap between the plain low type surface and the durable pavement. It is a maintenance and not a construction problem. It must be kept in mind that the great bulk of highway mileage is either surfaced with a low type surface or not surfaced at all and this will continue to be true for many years to come. A comparatively small mileage of our main highways will be paved each year with high type surface, but finances will not permit the building, within a few years, of all primary or state systems of highways with a durable pavement. Until this can be accomplished we must adequately take care of highway traffic in the best possible manner within the means at hand and from the experience already had by many of the states it may safely be stated

that a gravel road may be made a smooth, safe and dustless road at a moderate annual cost, in fact, at a less annual cost than the interest on the investment in a high type road for a limited time. By this it is not meant that paving with high type surfaces should be discouraged, but on the contrary surface treatments should serve only as a stepping stone to higher types. A gravel surface treatment is not a pavement and cannot be treated as such. To do work by any of the above methods and not make provisions for follow up maintenance is to invite failure. However, where the work is properly done and properly followed up a gravel road can be strengthened to carry increased traffic economically and safely. About 450 miles of gravel surface were treated with light tar by the mixing method in Wisconsin during the seasons of 1923, 1924 and 1925 and it is believed from the results obtained thus far that in this type of treatment is a solution of the dust problem on gravel roads.

The problem is plainly one of making the best of that which we have and to proceed gradually along sound business lines and provide for the motoring public a safe, efficient, dustless highway until a high type pavement can be built.

SOIL RESEARCH IN OHIO

By F. H. Eno, Professor of Municipal Engineering, Ohio State University, Columbus, Ohio.

The soil research being conducted in Ohio is a cooperative project between the Ohio State University, the Ohio State Highway Department and the U. S. Bureau of Public Roads.

The laboratory work has now been under way for about one and one-half years. We have secured a background or foundation of experience and knowledge of soils that furnishes a very good basis for their identification. More than 250 soils have been variously analyzed in the laboratory. We have followed largely the path blazed by the U. S. Bureau of Public Roads in their soil laboratory. I think, however, we originated the percolation test which we are still seeking to develop into a more uniform expression of that soil characteristic.

One fact we have striven to keep in mind is, that road engineers will have little to do with any new-fangled ideas that do not appeal to them as to the practical application, and especially are contractors obtuse to any theory that may be advanced which cannot be practically worked in the field.

We believe that the percolation test can be made very simple, can be correlated with the mechanical analysis of the soil, and will mean to both contractor and engineer direct knowledge as to whether in a given soil, tile drainage can or cannot be used to advantage. It may also call to their attention that in order to rid the subgrade beneath the pavement of the evaporated and then condensed capillary water, it will be necessary to install a porous and well-drained subbase of slag, gravel or broken stone.

The old slaking test is now being tried with a view to standardization. It is believed that being a simple test it will appeal to road engineers as a quick and definite test to show them a particular need on road maintenance, namely, that upon certain sections of soils, soil indicated by this test, the shoulder next the edge of hard pavements should be constructed of gravel, slag or broken stone and surface treated with bituminous material in order to prevent overrunning traffic from cutting ruts, thus making possible the quick slaking down of the soil beneath the edge of the pavement and the consequent destruction of the pavement.

Various treatments of the sub-base with the idea of stablizing the sub-base soil are now being tried out in the field beneath Federal Aid roads. Thus far we have tried 2, 4 and 6 in. layers of porous materials, such as sand, gravel, slag and broken stone, also admixtures with the top 2, 4 and 6 in. layers of sub-base soil of hydrated lime and cement in various percentages by volume of the soil layer.

I believe our work last fall has proven conclusively that admixtures are not practicable. They are only of value in dense clay soils, and such soils, when wet, will not break up to permit mixing. The delays incident to rainy weather would more than offset any advantages gained.

Hydrated lime mixed with clay soil makes some very marked changes in the soil characteristics, as shown by our laboratory tests, but we cannot recommend it for practical purposes upon hard surface construction. We are trying to develop a plastic or bearing power test upon soils in the laboratory in order to find out at what point in their moisture content they become unstable for road sub-grades. The experiments have not

been carried far enough yet to give a standard method.

For nearly the whole year and a half observations have been made at some 60 or more stations in the field, scattered over the north and south limits of Ohio, to determine the varying moisture content of the soils throughout the year. Samples were taken at the surface and at 6, 12, 18 and 24 in. in depth and moisture content determined. This series of tests, begun in conjunction with the plastic tests, should give us some very valuable information.

Levels have been taken upon some 30 different pavements from different soils to find out how much displacement takes place due to swelling and contraction of soil, freezing and thawing and expansion and contraction of paving material itself. Of course, all this may enter into our observations and it will be difficult to separate out the effect of any individual agent, but the total effect can be determined. In taking moisture samples, we have kept a record of the depth of frost at each station.

The routine tests of capillarity, moisture equivalent, moisture holding capacity, volumetric change, etc., have been carried on upon practically all the soils brought into the laboratory.

ACCOUNTING METHODS FOR WATER WORKS

By Harold D. Smith, Municipal Consultant, League of Kansas Municipalities

(Editor's Note: The following article is from a recent issue of "Kansas Municipalities.")

The water plant is a utility of more than ordinary public interest. In fact, its almost universal public ownership might well class it as a governmental function along with police and fire protection. Certainly fire protection cannot be logically considered apart from the water supply. In whatever way the water plant may partake of the functions characterized as governmental, it is, in fact, a business and should stand on its own feet financially, receiving credit for all service rendered in proportion to the cost. That many water utilities do not stand on their own feet, but lean heavily on general taxation, is well known. Yet the water plant too frequently does not receive credit for fire protection and water used for public services, such as street and sewer flushing, which should be a charge against general taxation and not the domestic consumer. Probably in 50 per cent of the Kansas cities, the water plant is not credited with fire protection service which requires a heavy outlay, in plant and distribution system, far in excess of the demands of domestic and industrial consumption to say nothing of credit for other public uses of water. Since the investment for fire protection represents from 30 to 50 per cent of the total it becomes a very important matter in the financial planning of the water plant. Some of the states have statutory limitatiions on the tax levy for hydrant rentals placed without the slightest regard for the cost of fire protection or its equitable distribution. These limitations serve no useful purpose and should be removed to allow the plant to be placed on a sound financial basis. If the plant is to stand on its own feet financially, it must receive credit for each service rendered.

Uniform Accounting Procedure

The accounting procedure of privately owned utilities under the control of the state regulatory bodies is set forth in great detail in what is called uniform accounting procedure. Attention is frequently called to the fact that practically no state supervision is exercised over the accounting procedure of municipally owned water plants and no effort to effect uniformity in the account. On account of the frequent turnover in the officials ultimately responsible for the administration of the water utility, centralized supervision over accounting methods offers possibilities for better management, but such a plan violates the spirit of local autonomy and is of doubtful value. Our legislature already finds itself swamped with a multiplicity of perplexing problems and it is doubtful if we should add more. Moreover, the same reasons which justify a uniform accounting procedure in privately owned utilities do not hold for the municipally owned water plant. The state regulatory body must have reliable information from uniform sources for use in adjusting rate schedules to produce a fair return on the fair value of the property. In water works municipally owned and managed the problem is not one of regulating private profit but of obtaining accurate inofrmation on which to base a rate schedule that will insure a healthy financial condition of the plant and reasonable equity between classes of consumers. However, for this purpose, just as high a type of accounting procedure is necessary in the municipally owned as in the privately owned

plant. Since operations of water plants are practically the same there will be essential uniformity in accounting procedure if all these operations are properly accounted for.

It is not only the lack of uniformity in accounting methods but the absence of adequate accounting that contributes to the worthlessness of financial data collected uncritically for general statistical purposes. This is the kind of financial data so freely used by government ownership and anti-government ownership propagandists to prove their respective arguments. More accurate comparative data for use of the management as a basis for judgment will be made available by better accounting. That present methods of accounting for water plants operations leave much to be desired, is without question.

Character of Water Utility

Accounting for the operations of a water works, in common with similar monopolistic utilities, presents a special problem differing from that in competitive business as, for example, the wholesale or retail business. In many respects, accounting procedure for a water works is much simpler than that used in the business operations mentioned. There is not the element of uncertainty and speculation to contend with. The product is highly standardized and the market certain. Our demand for clothes may fluctuate with changing fashion or our ability to pay, but our demand for water remains essentially the same. There is no waiting for better prices—production and consumption are almost simultaneous. The product is consumed locally and the number of customers certain. Furthermore, the water plant is on a cash basis. These characteristics contribute further to the simplicity of the accounts and lessen the chance of loss to the management. Yet contrasted with industrial accounting, the accounting methods of the water works plants are generally inadequate. Economic pressure has forced better accounting methods in industry. Diminishing profits stimulated the managements to look more carefully into the cost, but no such motive operates in municipal ownership. There is no possibility of bankruptcy, and inefficiency where it exists is entered as a charge against the community.

Three Examples

I wish to use three actual examples which have come to our attention from smaller cities. In city No. 1, the operation of the water plant until recently was in the hands of one man while the quarterly bills were collected by the marshal. The marshal furnished his own books which consisted of a pocket size memorandum for recording readings and a small stock ledger form to enter those paying their bills. The marshal did not have individual customer ledger sheets or even a standard form of meter reading slips. The customers having paid their quarterly water rent simply had the amount paid entered for the quarter opposite their names. No charge entries were made in the book to show how much each customer owed and it was even impossible to find evidence to show what these customers had consumed for the period of time previous to the last year. There were at least 250 consumers in the town and the minimum charge was 25c a month, or $3 a year. Considering the minimum charge only as a monthly rent for each customer, the plant should have earned during the year on minimum charges $750. The railroad used at least $125 worth of water each quarter and paid the city at least $500 a year for the water used for their tank. Considering both sources of revenue, the plant should have collected at least $1,250 in a year. An audit of the earnings of the water plant, showed that only $900 was deposited as having been collected for the services of the water plant. This shows that the plant lost at least $350 when considering the minimum of services rendered. However, there were many customers who used much more than the minimum charge and there was also some money received from miscellaneous sales so that it is quite likely that this small plant lost at least $600 a year because of unbusinesslike recording of its transactions.

City No. 2 maintained an excellent water plant which had been considered a success by the city administration. However, an audit of its books showed that this plant was losing from one to four hundred dollars each year chiefly due to laxness in enforcing the city water customers' regulations. A great many people moved in and out of the town each year and quite a number of these without first paying their utility bills. The rest of the loss incurred was due to the accounting system used which did not permit an easy checking up of each customer's business. Meter reading slips were so arranged that the subtractions showing the consumption of the customer could not be logically made. The individual customer's ledger was not conveni-

ently drawn up so that it was very difficult to check up on the amount consumed and the cost thereof before sending out monthly bills. These losses had been going on for ten or twelve years without the knowledge of the city clerk, the water superintendent, or the city council.

In city No. 3, there was neither an adequate accounting system for the utilities, nor any water plant regulations whatever. Every half year the city treasurer was given a list of the names of those who had not paid their quarterly bills and the commissioner was given 10 per cent on all the money he collected. These delinquent bills often amounted to several hundreds of dollars and according to the treasurer's own statement, he was doing well to collect one-third of the amount.

A loss of several hundred dollars a year means a great deal to the small city. Such losses as these can be prevented and the plant collections made nearly 100 per cent of its earnings by the installation of an adequate accounting system, the adoption of an ordinance regulating the business relations of the water customers with the plants and its rigid enforcement by the city administration. A certain period should be allowed for the payment of bills and after the expiration of this time a penalty should be attached. If after the lapse of an additional period the bill is not paid, the services should be discontinued and a charge made for their continuance. Cities that enforce these regulations find little trouble in collecting practically all their revenue by the 10th of the month, while in cities without regulations or which fail to enforce them, collections drag over the entire month and often for several months. Laxness in this regard gives the customer who intends to move away an opportunity to leave his bill unpaid. Even where regulations are enforced the enforcing officer often finds that the customer has moved away when he arrives on property to turn off the water. To save the city from such a loss the customer's deposit equal at least to the average monthly or quarterly consumption of all customers should be made before services are granted. The accounts carried on the book should be in the name of the owner in fee simple of the property served and he shall be held liable for water used upon the premises whether he is occupying them or not.

Customer's Deposits As Trusts

Customers' deposits should be handled as a trust fund. They should not be placed in the water, general, or any other fund except the one especially designed for that purpose. Revised Statute 12-822 makes it unlawful for any public or private utility to accept a deposit unless kept in a separate account showing the date on which such deposit is received, the name and amount. It is further provided that 4 per cent interest shall be paid on the deposit and credited to the customer on 1st of January of each year. In spite of this statutory provision deposits are often put in the general or water funds and spent as other revenue. Records are often inadequate and customers withdrawn from service are paid deposits they never made. The adoption of a single deposit receipt and a separate ledger to record the receipts and disbursements of the deposit with interest accruing thereto will provide sufficient record and eliminate this difficulty.

Except in a few of the larger cities the responsibility for the collection of water revenues falls upon the shoulder of the city clerk. In fact, it is often the major duty of his office. In the smaller places the city clerk often reads the meters, calculates the bill and collects the money on the premises, leaving notices at only places where the customer is absent. In some cities the persons reading the meter makes out the bill and leaves it with the customer to be paid either at the city clerk's office if he has a permanent office, or at a local bank. These methods may work well according to the integrity and ability of the person using them, but they are not to be encouraged, and are unquestionably wrong in principle. All revenue should be received over the counter either in a bank or in the city clerk's office or in the water department office in case of larger cities. There is little chance of loss of money or records when the principle is followed. It is a good habit for the customer to form to come monthly or quarterly as the case may be, to a central office to pay his utility bill. To my knowledge there are at least two cities where the customers go to the city clerk's office before the 10th of the month to pay their water bill without any notice whatever. It is poor practice to go into the field to collect a back bill. The service should be cut off until the bill is paid. Adequate customer's regulations are essential if the utility is to be protected against bad bills.

Safeguard Records

One city clerk in a small town contrived a very compact and novel record

in which he combined meter reading book, receipt and ledger. This he carried with him in the field. While receipting for the payment of a customer he stood near an open well with his compact record under his arm, until by accident it slipped out and fell into the well. It is needless to say that he lost no time in fishing it out as it contained the only record of the utility with considerable outstanding revenue. The best system for collecting and recording utility revenues, now almost universally used by utility operators, is very simple in operation, accurate in its checks, and susceptible to only minor variations. Most of you already use it in part or in its entirety and it is to be recommended to all cities having water plants or other utilities. The procedure based on a metered system is as follows: the city is laid out in routes which the meter reader, equipped with a bound book of meter reading slips, follows. These slips have been previously filled out with an account number, name and address of customer, location of the meter and any other data deemed necessary. Each slip provides space for the present and previous reading for each month of the year, reversed in order to facilitate subtractions to determine amount consumed. The meter books are brought to the office after the readings are completed and the amount consumed and the charge is calculated and entered into an individual customer's ledger sheet usually large enough to contain the customer's business for several years. These charge entries are made according to an account number on the reader's slip and in the name of the property owner. At the same time a bill card is made out to be sent the customer. The amounts on the cards should be made to balance exactly with the entries in the ledger. The customer is asked to bring the card to the office when he pays his bill. The card is devised so that it may be clipped, one part being returned to the customer as a receipt stamped paid and the remainder retained by the clerk or cashier for the purpose of making the paid entry in the ledger for that account number.

Some cities do not use any ledger whatever, or, if they use a ledger, do not maintain a separate sheet for each individual customer. Often the bills are collected and receipted for and no record other than the receipt is maintained. This practice is certainly to be condemned as unbusinesslike and subject to error and difficulties on account of the fact that there remains no check or no balance whatever. Many cities find it the best practice to send out bill cards because the customer usually wants to know the amount of his bill and because this bill, when returned to the office for payment also serves as a receipt. However, it is needless expense to send out bills where the customer is in the habit of coming monthly to make payment. The question of whether bills should be sent through the mail or delivered by the meter readers or boys for that purpose, is one which must be decided locally. I believe, however, that the preponderance of practice is in favor of sending the cards through the mail because there seems to be less chance that the card will not be properly delivered.

Office Equipment Necessary

In performing these operations good office equipment greatly lightens the work. Addressing the bill cards is a laborious job which may be quickly done by the use of an addressograph. The hand-operated addressograph costs a little more than a typewriter and, as a labor-saving device where address lists are largely permanent, they cannot be equaled. A dating stamp may be used to date the cards and if desired the account numbers may be entered with the numbering stamp.

To facilitate the calculation and entering of the charge upon the bill card, a stamped calculator may be used. When these bills are returned for payment a coupon clipper clips the cashier's coupon from which he makes the 'paid" entry in the ledger and stamps "paid" on the remainder of the card as a receipt for the customer. Some utilities use a specially devised cash register for this operation. These labor-saving devices greatly reduce the labor of the work of billing for water rates and their use should be encouraged in the offices of city clerks and water departments.

There remains for our consideration the matter of expenditures of the water plant. It is not enough to list these plant disbursements in sequence. This simple procedure gives the management no information for determining the unit cost or the total cost of the various operations. . The management must have this data, or no sound judgment is possible as to the most economical methods. The size of the water plant and intricacies of its operation justify a very careful classification of expenditures. It is an estimate of these operations which a good accounting system should produce.

Some municipalities already separate utility expenditures after some convenient classification. In privately owned and operated utilities under state regulation, these classifications are set forth in great detail. The simplest classification we can think of would divide the disbursements between operation, maintenance, capital outlays and general expense. Under these headings for a water plant, we must have pumping, purification, distribution, office and plant and extensions. These may be divided into objects of expenditure such as labor, fuel, material and supplies, miscellaneous, and any further classification the management may desire.

Uniformity Needed Over Entire State

If a certain uniformity of classification were developed over the state, the exchange of costs would be made more valuable than it now is. However, the most accurate and detailed cost data may be erroneously construed if taken too far from the physical conditions surrounding the plant. Cost finding and expense analysis occupy a considerable part of the accounting procedure of industrial plants. It should occupy a greater place in the accounting procedure of the water plant, especially since the rates are based on the cost of the service. In order to establish a scientific rate schedule such a classification as here suggested is absolutely essential, but this important subject need not be treated in further detail in this paper. However, the space devoted to it is in no way proportional to its importance.

INVESTIGATIONS OF STREAM POLLUTION

By W. H. Frost, Surgeon, United States Public Health Service, in Charge of Stream Pollution Investigations

In March, 1901, Congress provided for the erection of a laboratory by the United States Public Health Service "for the investigation of infectious and contagious diseases and matters pertaining to the public health," and in the same year a division of scientific research was organized in the Bureau of the Public Health Service. Therefore the year 1901 may be said to mark the establishment of systematic and continued scientific investigation as a recognized function of the Public Health Service. Considering the role which sewage-polluted drinking water was playing at that time in the spread of typhoid fever and other infectious diseases, and recalling that the membership of the Hygienic Laboratory Advisory Board included the great leader in sanitary science, Prof. William T. Sedgwick, it was inevitable that attention should have been directed at once to the importance of comprehensive studies of stream pollution in relatiion to disease. That this was true is evidenced by frequently recurring references in the annual reports of the director of the Hygienic Laboratory during its early years, but the number of other problems was so great and the resources of the laboratory were so limited that for several years work in this field was of necessity limited to occasional studies of local water supplies, undertaken usually in connection with investigations into the causes of the epidemic or endemic prevalence of typhoid fever in various localities.

In 1910 the first systematic investigation of the status and effects of sewage pollution in any large area was begun by the assignment of A. J. McLaughlin, surgeon, United States Public Health Service, to make a survey of cities in the Great Lakes region, with instructions to investigate the extent of the pollution of their water supplies and its relation to the prevalence of typhoid fever and other water-borne diseases, and to examine State and municipal ordinances relating to its control. Upon the completion of these surveys and of the reports thereon, which were published in bulletins of the Hygienic Laboratory, Doctor McLaughlin was assigned, by request of the health authorities of States bordering on the Missouri River, to make a survey of the sewage pollution of that stream. In this work, which was carried out during the summer of 1912, Doctor McLaughlin for the first time had the assistance of another officer of the service and was enabled, through the cooperation of the health authorities of the States concerned and of certain cities on the river, to establish several laboratories and make a rather extensive series of bacteriological examinations.

By the time this work had been brought to a close the International Joint Commission, established under the treaty between the United States and the Dominion of Canada, had taken up the question of regulating the pollution of international boundary waters, and, on request of the commission, Doctor McLaughlin was granted leave of absence from the service to accept appointment as chief sanitary expert and director of field work in investigations undertaken by the commission. These studies al-

though undertaken independently by the International Joint Commission may, in a certain sense, be considered as an extension and continuation of the survey of Great Lakes cities previously undertaken by Doctor McLaughlin for the Public Health Service.

In the meantime by an act approved Aug. 4, 1912, Congress had extended the function of the Public Health Service to include, among other added duties, that of investigation "the diseases of man and conditions influencing the propagation and spread thereof, including sanitation and sewage and the pollution, either directly or indirectly, of the navigable streams and lakes of the United States," and in 1913 made a special appropriation, which has since been continued annually, for carrying out these provisions. The Public Health Service was thus enabled for the first time, in 1913, to establish field laboratories at such points in the United States as might be most suitable for special purposes and to employ a scientific personnel especially qualified to conduct investigations in various fields of research.

It was under this extended authority that in the summer of1913 a group of sanitary engineers, chemists, biologists and bacteriologists was assembled and a beginning made on a concerted plan for investigations relative to stream pollution. As originally organized, the work undertaken comprised the following main divisions:

1. Studies of the biochemistry of sewage and industrial wastes were undertaken at the Hygiene Laboratory under the direction of Earle B. Phelps, affiliate, American Society of Civil Engineers, who was appointed in that year as chief of the division of chemistry in the laboratory. These studies were devoted especially to testing and developing the application of biological oxygen demand determinations to the measurement of the potential polluting effect of sewage and the capacity of streams for its oxidation, a field of research to which Mr. Phelps had already made notable contributions.

2. Intimately connected with these was a series of studies, likewise under the direction of Mr. Phelps but carried on for the most part at various points outside of Washington, D. C., attempting by means of experimental installations, to devise better methods for the treatment of various important industrial wastes for which economical and effective processes had not previously been evolved.

3. Under the direction of H. S. Cumming, surgeon, United States Public Health Service, the present Surgeon General of the service, a study of the pollution and natural purification of the Potomac River was undertaken. The Potomac was selected as a type of tidal stream, and special attention was paid in this study to the effect of sewage from the city of Washington on the waters near the mouth of the river, where important shellfish beds are situated. This investigation, which was completed in the summer of 1914, was then extended and continued as a survey of the sewage pollution of various coastal waters, with special reference to the contamination of shellfish.

4. At the same time, in the summer of 1913, work was begun on a study of the pollution and natural purification of the Ohio River, which was selected as a typical large inland stream, receiving sewage, usually without treatment, from all cities on its watershed, and at the same time being used by many of these cities as their source of water supply. Headquarters for this work were established in Cincinnati, Ohio, with subsidiary temporary laboratories at five other points along the river.

These several studies although conducted by working parties, organized into separate units, were closely knitted together by being all under the direction of the Division of Scientific Research in the Bureau of the Public Health Service and by the intimate relations which were maintained between those in charge of the several organizations. In fact, they were considered and pursued, not as separate studies, but as independent parts of a common and general plan. They were all continued, substantially as originally organized in 1913, until 1917, when it was necessary to discontinue them in order to utilize their personnel in various other more urgent duties during the period of the World War.

By the latter part of 1919, when it was possible to resume the investigations, the original personnel had become much dispersed by necessary assignments to other duties and by resignations. Likewise, the funds available for these investigations, although not actually reduced to any great extent, were relatively diminished by the material increase in all scales of cost, so that in the reorganization it was necessary to discontinue the investigations of coastal waters, which had been brought to a fairly definite conclusion, and to reestablish the other work at a single base in Cincinnati,

which has since served as central headquarters for experimental studies of stream pollution and as the base from which parties have been sent out for work in the field.

Shortly after this reorganization the Surgeon General recognizing the need for authoritative advice in the planning and conduct of these investigations, requested Dr. Stephen A. Forbes, professor emeritus of biology at the University of Illinois and director of the Illinois State Natural History Survey; Dr. Edwin O. Jordan, professor of hygiene and bacteriology at the University of Chicago; Langdon Pearse, member American Society of Civil Engineers, sanitary engineer of the Sanitary District of Chicago; and Earle B. Phelps, affiliate, American Society of Civil Engineers, consulting sanitary engineer, of New York, N. Y., to serve as consultants in studies of stream pollution. These consultants, meeting once or twice each year with the staff engaged in the investigations, and keeping in close touch with the progress made, have rendered generous and valuable assistance in shaping plans, devising methods, and interpreting results. Subsequently Joseph W. Ellms, member American Society of Civil Engineers, consented to serve as special consultant in studies of water-purification processes and has had an active share in the development of investigations along this line.

Since 1919 the principal field investigations undertaken from this base have been—

1. A study of the pollution and natural purification of the Illinois River, undertaken chiefly to check and extend observations previously made on the Potomac and the Ohio Rivers relative to the laws governing natural purification in streams.

2. A survey of representative municipal sewage-disposal plants in various parts of the United States to collect information as to their efficiency and cost in actual operation.

3. A collective study of municipal water-purification plants, chiefly rapid sand filters, as operated in a number of cities on the Ohio River and elsewhere, with a special view to ascertaining more precisely the relations between pollution of the raw water and quality of the effluent under varying processes and conditions of operation.

Along with these field studies experimental investigations have been consistently pursued in the Cincinnati laboratory, chiefly along the following lines:

(a) Attempt has been and is being made, so far without notable success, to reproduce on a small scale, adapted for intensive experimental study, the phenomena of bacterial purification which are now known to take place in natural streams. This has included as a necessary item rather extensive research into the biology of various plankton forms in relation to bacterial purification.

(b) Studies of the biological oxygen demand of sewage, industrial wastes, and polluted river waters have been continued in the endeavor to establish more definitely the laws governing the natural processes of oxidation in streams and to check and improve the precision of methods for making the determinations required.

(c) As an extension of the collective study of municipal filter plants which was completed in 1924, experimental studies are now being made of the relation of the pollution of raw water to the quality of effluent obtainable by rapid sand filtration and chlorination, utilizing an experimental plant on the laboratory grounds which is designed so that the conditions of loading and operation can be varied at will through a wide range.

In addition to these studies, which have been pursued at Cincinnati, work has been going on for several years at the Hygienic Laboratory under the direction of Dr. William Mansfield Clark, in a study of the physical chemistry of coagulation, with special reference to applications in water purification.

It would be impossible within a brief space, and is, moreover, not pertinent to this paper, to relate in more detail the history of the various undertakings which have been outlined, nor will any discussion of the results be attempted. As far as they have matured, they have already been made generally available in a considerable number of publications.

In conclusion, it will be more appropriate to review briefly the broad general considerations which have determined the scope and direction of such studies as the Public Health Service has undertaken in this field since it has been in a position to make and pursue any general plan, that is, since 1913.

The first consideration, of course, has been the limitation of available resources, which have sufficed in most years for the maintenance of a staff not exceeding 6 to 12 workers in the higher grades, enough to form a compact group for consistent work on definite lines, but obviously not sufficient to permit of any wide dispersion. The governing con-

siderations in deciding on the use to be made of these resources have been: The existing status and trend of conditions with respect to sewage pollution in the waterways of this country; the status of sanitary science as applied to devising the remedial measures necessary to meet present and future conditions; and the facilities available through State and municipal organizations, independent institutions for research, and the engineering profession at large for conducting such further investigations as may be required.

With respect to sewage pollution, the status in the United States was, in 1913, and is today, that the greater part of the sewage from cities, probably not less than 85 to 90 per cent of it, is discharged without treatment into the most convenient stream. Where the dilution is insufficient for prompt oxidation and removal of the sewage, the result is the establishment of a gross nuisance in the immediate vicinity, offensive to the sense of decency and frequently injurious to the financial interests of the community responsible for the pollution. The remedy for this, however, is at hand, as the ingenuity of sanitary engineers, chemists, and biologists has already devised effective means for the treatment of sewage at reasonable cost, and self-interest may be relied upon to impel cities which suffer nuisance from their own sewage, to avail themselves of this remedy. The abatement of such gross nuisance is usually a local matter, requiring no broad plan of concerted action between widely separated communities, and, as the principles of the required treatment are already well established, such special investigation as is required is usually a matter of detail, to ascertain the particular process or combination of processes which will serve most economically and effectively in the particular case. Obviously, such investigations are the business of the State and local authorities and of the practicing engineers retained by them rather than of a Federal agency.

The more usual and more serious result, where dilution and current are sufficient to prevent immediate gross nuisance from the discharge of untreated sewage, is to contaminate the water supplies of other cities taken from the same river system at downstream points, or, in the case of tidal waters, dangerously to contaminate waters from which shellfish are taken. In the case of public water supplies necessarily taken from such polluted sources the immediate remedy is artificial purification of the supply. For this, again, sanitary science has already provided the means in various processes of treatment, economically practicable and of such efficiency that they may be relied upon to give safe effluents from water which is highly but not definitely polluted. In 1913 there were, to be sure, a number of cities using dangerously polluted water supplies, but in every instance the remedy—installation of adequate water-purification works—was obvious, and such investigations as were required were not general, to ascertain the practicability of a remedy, but local and special, to decide upon the details of the installation best adapted to apply established principles to the problem at hand. It is clear that these local investigations, like those required for local sewage treatment installations, are not the function of the Public Health Service.

In general, the situation up to the present time has been that, notwithstanding the customary practice of discharging raw sewage into streams, those cities which have had to take their water supplies from the rivers thus polluted have almost invariably been able, by applying established processes of artificial water purification, to secure water supplies of good, safe quality. This has been true because the volume of the larger rivers is such as to afford great dilution, even for the sewage of larger cities, and because of the distance between the sewer outlets of these cities and the water-supply intakes of other cities downstream are such as to permit of great reduction in pollution by the natural agencies of purification. Similarly in coastal waters, although they are grossly polluted in the immediate vicinity of cities discharging sewage, there are still great areas sufficiently free from dangerous contamination to be suitable for shellfish culture. Consequently, local measures, namely, the installation of water-purification plants for safeguarding water supplies and the condemnation or local protection of the relatively small areas unfit for shellfish culture, have suffered for immediate protection against the dangers of sewage pollution. The protection has not been perfect, but it has tended to become progressively better in recent years, as evidenced by the enormous decrease in prevalence of sewage-borne diseases.

Looking to the future, the conditions foreseen and the remedies which must eventually be applied become more com-

plex. With the growth of urban population, which still continues at a rapid rate, the sewage pollution of streams and coastal waterways must increase, and sooner or later, in the absence of anticipatory control, it seems inevitable that eventually the pollution will become such that water-purification plants of the highest attainable efficiency will not be able to deliver consistently safe effluents. To guard against this condition it will be necessary, perhaps in the near future, to limit the pollution of such inland streams as are necessary sources of water supply by such measure of sewage treatment as will suffice to keep the pollution at water works intakes within definite bounds.

This, however, is an extraordinarily complex matter, not only from the administrative point of view, with which this presentation is not concerned, but equally from the scientific viewpoint. It implies a concerted plan of control applied to an entire river system as a unit, a plan in which, presumably each community will be required to limit its contribution of sewage pollution, not in the interests of its own citizens but the protection of other communities downstream, usually including cities in several States. Safety demands that the measure of control exercised be adequate; justice demands that it is distributed among the communities on some definite and equitable principle; and economy demands that it be not more rigid than is actually necessary to insure the requisite protection to health.

The data needed for laying out any such comprehensive plan for controlling the pollution of an entire river system, with due regard for the considerations of safety, equitable distribution of the burden of control, and economy, are as follows:

First.—It is necessary to have established some quite definite and objective criterion of the quality which is to be maintained in the water supplies taken from the river as they are delivered to the consumers after artificial purification. This criterion or standard must be in terms of measurable characteristics, determinable by quantitative bacteriological or chemical examinations. It must be rigid enough to insure safety beyond any reasonable question, but not much more rigid than is actually necessary, lest it impose an excessive burden of costs.

Second.—It is necessary to have a fairly precise knowledge of the reliability and efficiency of such purification processes as can be applied at a reasonable cost to purification of the raw water available at the best practicable intake, for it is this efficiency, taken in connection with the standards set for the final effluent, that determines the upper limits of the pollution which may be tolerated at the intake.

Third.—It is necessary to know what proportionate part each of the sewered communities, situated at varying distances upstream, contributes to the pollution existing at any given intake, for otherwise it is impossible to estimate what effect elimination or reduction of the pollution from any single community will have in reducing the pollution in the intake zone. This, in turn, implies, a fairly precise quantitative knowledge of the laws governing the processes of natural purification, and of how they may vary in different types of streams in relation to various climatic, seasonal, and hydrographic conditions, for it is only through knowledge that these great protective processes which nature has provided may be used most effectively, and not to use them is to waste a natural resource of enormous economic importance.

Unfortunately, sanitary science has not furnished such full and precise knowledge as will be required on any of these points, especially in regard to the natural agencies which tend so greatly and rapidly to reduce bacterial contamination and which constitutes one of the main reliances for protection of health. Moreover, it seems unlikely that it will be possible to borrow this knowledge from the experience of other more densely populated countries, as the writer knows of no other country having simliar problems in the control of stream pollution on a comparable scale and for a similar purpose; that will probably have to be studied successfully before a solution becomes necessary for some of the great river systems in the United States.

It is with these considerations in view that the Public Health Service, with the advice of its consultants, has consistently directed its investigations of stream pollution along the lines described, devoting a large part of its effort to such undertakings as the attempt to improve technical methods for laboratory determinations, to evaluate the efficiency of filtration plants under the adverse conditions of loading which may be anticipated in the future, and to add something to the present scanty knowledge of the laws of natural purification. Information of this

kind, even if it may seem at this time to be more or less academic, will be essential to sound sanitary engineering practice in the future. Moreover, it appears to be preeminently the kind of information that a Federal agency should collect, because it is of general, not local, application, and because it involves such long-continued and laborious investigations as are not likely to be undertaken by private agencies, or even by State and municipal organizations, busy as they are with more immediate administrative work and with the necessary local studies incident to it.

However, while the Public Health Service is confident that this general policy is sound, it cannot, of course, feel equally confident that the sequence which is being followed in the development of these studies is the best possible or that the methods which are being applied are always the most effective. For guidance in such matters the service relies primarily on its special consultants, but, in addition, it always has sought and sincerely desires the criticism and constructive advice of the entire sanitary egineering profession. Therefore, the opportunity of outlining the purposes and present status of the work to the engineers of the country is especially appreciated, in the hope that they will further it by their criticism and advice.

BUS SUPPLEMENTING TROLLEY CAR

Buses are increasing the local transportation service throughout the United States, but not supplanting electric railway cars in any marked degree, a national survey just completed by the American Electric Railway Associatiion shows.

The erroneous impression that the bus is supplanting the electric car is doubtless due in part to the failure of editorial writers and others to give details regarding the size of rail operations abandoned.

For instance when it recently was proposed to substitute buses for cars carrying about 2 per cent of New York City's surface riders, many newspapers hailed the suggestion as meaning the passing of the trolley in New York. Of course, this was ridiculous. Trolleys are carrying one-third of all New York riders. Subways carry most of the rest.

The bus is finding its place in serving as a supplemental carrier to the electric and steam car. It cannot carry large numbers of persons as cheaply or quickly in congested centers as the electric car. Where passengers are few and scattered, the bus can give a service, even though uneconomical, that otherwise would not be possible. In attempting to handle mass transportation, the bus adds to traffic congestion, provides slower transportation and increases the fares.

This has been proved repeatedly where cities have attempted to substitute buses for trolley service. Such tests have been made in half a dozen cities of more than 50,000 population. All have gladly returned to trolley service. These cities include Des Moines, Akron, Saginaw, Bridgeport and others. The fact that no city of over 50,000 in the world today is being served exclusively by buses proves the necessity for the street car.

More than 300 electric railway companies are utilizing the bus in the place where it belongs—that of giving supplemental service. Routes operated embrace more than 12,250 miles, with some 6,000 buses. Most of this service is over new routes.

Since 1915 buses have supplanted only about 2,000 miles of track, mostly in sparsely settled sections. During this same period electric railways alone have added by bus and rail, more than 15,000 miles of service. Their total combined service today is almost 60,000 miles.

More new electric railway track has been built in the last ten years than has been abandoned. However, since most of the abandonments have been of branch lines, statistics on the number of passenger electric cars now in use in comparison with former years is a fairer test of the popularity of electric railway service.

There are 2,658 more closed electric cars in regular daily use today than there were in 1919. For instance, Los Angeles alone has 671 more cars in regular service than it had in 1919. Detroit 446, Chicago 425, Pittsburgh 175, St. Louis 155, Milwaukee 114, Indianapolis 67, Washington 56, Houston 55, Birmingham 45 and Dallas 31.

PNEUMATIC CONCRETE MIXER PATENT UPHELD

The United States Circuit Court of Appeals, sitting in New York City, affirmed, on May 3rd, the decision given

by Judge Hand in the United States District Court on August 4th, 1925, in favor of the Concrete Mixing & Conveying Co., of Chicago, in their suit against the Ulen Contracting Corporation and the Shandaken Tunnel Corporation for infringement of what is known as the McMichael Patent.

By this decision, the right to manufacture concrete mixers adapted to placing concrete pneumatically at a distance from the mixer—as in tunnels, foundation work, piers, etc.—is virtually restricted to the holder of the McMichael Patent and their sole licensee, the Ransome Concrete Machinery Co., of Dcnellen, N. J.

The original decree, by Judge Hand, gives great credit to the inventor, saying in part: "The appreciation by the inventor of the necessity of limiting the concrete to be conveyed to sections of moderate size and weight and his method by the second air jet of securing the cutting off of a segment from the mass of concrete and propulsion of this segment through the discharge pipe involves invention of a high order. His device has displaced all other methods for rapidly and economically conveying, lifting and placing concrete at long distances from the initial source of supply and has been used in numerous great enterprises."

VALIDATING TEXAS ROAD BONDS —A CRITICISM AND A SUGGESTION

By Wm. R. Watkins, Attorney, Fort Worth, Texas

(Editor's Note: The author of this article is the attorney who took the Archer County case up to the U. S. Supreme Court and whose arguments led to the now famous decision in Browning vs. Hooper. The article is reprinted from "The Bond Buyer" for July 10, 1926.)

Much that has been said on this subject is illuminating. Not so much because of the soundness or unsoundness of the views expressed, but because of the readiness of lawyers to disagree upon fundamental questions of grave public importance. I may be pardoned for the expression of an opinion when it is realized that for nearly three years I have held to a single view on the subject—successfully, it would seem.

It is my purpose to present the objectionable features of the validating law submitted to the Governor of Texas, and conclude with what I conceive, and have believed all along, is the only legislative solution.

The validation program of the Committee in Texas handling the matter comprehends, as to each road district, legislative re-creation of the district, validation of all orders of the commissioner's court relating thereto, validation of all taxes heretofore assessed therefor, validation of all outstanding road district bonds, and directions to the commissioner's court to assess and collect annually a general ad valorem tax on the property of the district for the purpose of liquidating the bonds.

The plan proposed presupposes in its favor two propositions: First, that the legislature originally had power to create these road districts as they were created, and has the power to do so now. Second, that in the levy, assessment and collection of a general tax for the purposes of these districts, a determination of the question of benefits is not essential.

To properly examine the question, it is necessary to turn aside a moment to the facts involved, other than those generally known. Of the 600 odd road districts in the state, I have been unable to find one whose boundaries were established with reference to the roads to be improved; none in which there was an attempt to include only benefited property, and none in which the moving consideration in the establishment of the boundaries thereof was other than to hold the tax rate of the proponents to the minimum, while at the same time outlining a territory in which the two-thirds majority vote necessary for the issuance of bonds would be included. This feature of the law was the subject of comment in the Archer County case.

In the Archer County case the Supreme Court substantially pointed out: (a) The levies for road building under the law are special assessments. (b) There was no determination by any one of the question of benefits—no justifiable apportionment of the burden. (c) There was no legislative selection of the taxing district. (d) That benefits must be considered in spreading the burden of a special assessment; and, (e) where the legislature itself does not establish the taxing district, notice and a hearing for the taxpayer before the assessment be-

comes irrevocably fixed, are necessary. The act was, therefore, declared repugnant to the due process clause of the Fourteenth Amendment of the Federal Constitution.

Fundamentally, an act that is repugnant to the Constitution is no act, no rights can be asserted under it and no action pursuant to it has any legal virtue whatever. If this were not so the very purpose of the guaranties of the Constitution would be nullified and protection would be afforded prospectively only. Under the rule it naturally follows that there have, in legal contemplation, never been any road districts, road bond elections, road bonds, or assessments therefor in Texas. We have only two things —improved roads, approximately 18,000 miles of them or 10% of the total mileage of public roads in the state, and, we have not paid for them to the extent of the unpaid bonds now outstanding.

Four propositions which are supported by respectable authority may be advanced as to why the validating program proposed is liable to defeat in the Courts:

First: The Courts regard substance and not merely the form a proceeding may take and as the purpose of the levy involved is a special one, as the district is specially designated to bear the cost of a special public improvement, the assessment must be considered a special assessment as distinguished from general taxes. This being true, it follows that apportionment is indispensable, and there must be a determination by or under the direction of the legislature as to what property will be benefited by the improvement in order for the assessment to stand.

The plan proposed assumes that the power of the legislature to impose a tax burden, general in name, can not be questioned, and, it does not provide for a determination of the question of benefits. It is apparent from the face of the proposed measure that if enacted, the legislature will not have considered the question.

Second: The defects in the old law are jurisdictional. The legislature could not have dispensed with a determination of the question of benefits, with apportionment, or in the absence of direct legislative action, with notice and a hearing. Therefore, the rule that the legislature may dispense retrospectively with what it might have dispensed with in the beginning, cannot be applied.

It is said that the legislature has no power by its own mandate to compel observance of invalid proceedings; that for the legislature to proceed without evidence, to declare such proceedings valid would be an usurpation of power which belongs to no civilized government; and, for it to proceed on evidence to declare them valid would constitute an invasion of the functions of the judiciary.

Third: The constitutional provision under which the law in question was adopted is prospective in its operation. It contemplates that before a valid contract for road improvements on credit can be made, and before credit can be obtained therefor, there must have been an election at which a two-thirds majority of the voting property taxpayers must authorize the credit and a tax levy therefor, under valid legislative provision. By providing this method of action in such matters, every other, by a familiar rule of constitutional law, is impliedly prohibited.

It is clear the constitution does not authorize an extension of credit to pay for construction after the improvement has been completed, and it may be questioned, therefore, if either the people by a vote or the legislature can now provide for payment of the cost of roads already built and unpaid for, in the face of this constitutional limitation.

Fourth: The power of the legislature to select property for, and to impose taxes, is not unlimited. When it is apparent the law is of such a character that there is no reasonable presumption that substantial justice generally will be done, but the probability is that the parties will be taxed disproportionately to each other and to the benefits conferred, it falls under the equal protection and due process clauses of the Fourteenth Amendment.

If the legislature undertakes wholesale validation as proposed by the committee under the facts hereinbefore outlined there is little question but that a property owner whose property is not substantially benefited in fact, could successfully claim impairment of his constitutional rights. And, justly so, because it is well known that the failure to consider the question of benefits under the old law has resulted in unconscionable confiscation in many cases.

* * *

The Texas Courts in dealing with cer-

tain of the other limitations in the Constitution relating to general taxation, have, conformably with the general rule, held that the power of imposing special assessments is vested inherently in the legislature, unrestrained and unlimited by any provision of the organic law. This was before the adoption of the constitutional provision under which the act considered in the Archer County case was passed. I may safely say then, that the power is unlimited save as regards those fundamental conceptions of the power, inherent and common to its exercise, and the provision of the Texas constitution hereinbefore discussed.

It is elementary that constitutional provisions relating to taxation are limitations upon an inherent power, rather than grants of it. It has long been established that where an assessment to pay the cost of a public improvement which has been constructed is void because of a want of power to make it, there is no obstacle to the imposition of another assessment for the same purpose. In fact when the benefit has been demonstrated by the construction of the improvement, mathematical exactness, which while not essential, can more nearly be attained in the apportionment and assessment of benefits than before.

The power to reassess generally being admitted, we are limited only by the provisions of the Texas Constitution heretofore discussed. This provision, it will be seen, limits the power of the legislature in the matters discussed as far as counties, political subdivisions and defined districts of the state are concerned, but not as to the state as a whole. There is no question, likewise, that in spreading a special assessment burden, the legislature may and of right should apportion the assessment according to the relative benefit to the property of the taxpayers. This is usually done by zoning. Where the zoning system has been employed its use has always been sustained in the absence of grossly arbitrary or fraudulent action.

The state of road improvement with moneys derived from bonds void for want of lawful authority to issue them, has proceeded to the point in Texas that unquestionably the legislature can declare a special benefit to the state therefrom and lawfully impose a special assessment upon all the property of the state to pay such of the cost thereof as remains unpaid. It may lawfully ascertain that this unpaid cost is equal in amounts to the unpaid bonds with interest, and authorize the assessments as collected to be paid to the bondholders. A special benefit to the state being ascertained, zones may be established and the assessment apportioned equitably among the various zones. Uniformity in the size or contiguity of property in the zones would hardly be essential, but satisfactory results can be obtained if the matter is intelligently handled by the legislature.

The only other method of settling the question I have been able to conceive is a constitutional amendment authorizing the legislature to provide for a reassessment of benefits in districts to pay the bonds. This, because of apparent obstacles, is the least advisable plan to adopt.

CHLORINATION OF SEWAGE

By Earle B. Phelps, Professor of Sanitary Science, College of Physicians and Surgeons, Columbia University, New York, N. Y.

(Editor's Note: The following is from a paper read before the Sanitary Section of the Boston Society of Civil Engineers.)

Although the chlorination of sewage was, in this country, at least, the forerunner of water chlorination, it has not thus far become a matter of such general interest. It is, however, worthy of some attention at this time because of certain unique advantages which it possesses in the general field of sewage treatment, and, again, because it illustrates quite clearly certain chemical and biological principles of the general process which are always obscure and often not apparent in the case of water chlorination.

Objectives of Sewage Treatment

Sewage treatment has three distinct objectives, often combined in one process but capable of clear differentiation.

These refer to the three types of nuisances resulting from stream pollution, namely, putrefaction of organic matter, resulting in odors, loss of oxygen and destruction of fish and other life; deposit of solids in slack water or upon shores and river banks; and dangerous bacterial pollution of water supplies, shellfish areas, and bathing places. The first of these has its remedy in oxidizing treatments, the so-called filters, and the newer aeration processes; the second, in

tank treatments, or screening; the third in some form of disinfection.

Many of the usual types of sewage treatment result in incidental improvement in the bacterial content of sewage. In particular, the oldest—intermittent slow sand filtration—and the most recent—the activated sludge process—may each be operated as disinfecting processes of rather high efficiency. In general, however, bacterial removal is but incidental to the primary purpose of these oxidation processes. For efficiency and economy in producing a reasonably disinfected effluent, either by itself or in conjunction with other objectives, chlorination possesses great merit. This is particularly the case when the other purposes of sewage treatment are not involved.

In the investigations made by the author for the International Joint Commission, for example, it was found that the Great Lakes and their connecting rivers possess ample powers of self-purification to care for the sewage of the cities along their shores, except for the bacterial pollution of the waters used below for domestic supplies. The recommendations laid down called for remedial treatment in which chlorination is to be the major feature. The sewage treatment program at Detroit has been based upon this finding. At Providence, chlorination of the partially important oyster-growing areas, and at Cleveland the largest chlorination plant in the world is operated primarily to protect the bathing beaches.

It seems reasonable to expect that chlorination will be more frequently employed in the future as its merits become better understood and as the need for better protection of our inland and coastal waters become more manifest. Such a development will be facilitated by a fuller recognition of certain chemicals and biological principles. The two more important principles will be briefly discussed at this time.

Chemical and Biological Principles

A principle of chemical disinfection, which holds also in thermal disinfection —pasturization of milk, for example—is that the process is a time-intensity product, or, more specifically in chemical disinfection, a time-concentration product. The bacteria destroyed by chlorine in sewage may be the same kinds as those destroyed in water, but in the one case we use concentrations of 10 p.p.m. or thereabouts, and in the other from 1 to 0.1 p.p.m., depending upon the water. This is not because it takes more chlorine to destroy more bacteria, but because the chlorine itself is destroyed or rendered non-available by organic matter. If we plot the concentration of available chlorine in a chlorinated sewage against the time of reaction, we obtain a rapidly falling curve of logarithmic type, dropping from, say, 10 parts at the beginning to zero in ten or twelve minutes. In a domestic water a similar curve is obtained dropping from 0.5, say, to 0.01 over a period of perhaps ten hours.

It would be unsafe to suggest that the areas under these two curves must be equal for equal results—in a percentage —for the relation is somewhat less simple than this. But there is some such definite relation. Some power or other simple function of the concentration, if plotted in this way, would undoubtedly yield an area strictly proportional to the total germicidal effect. A proper appreciation of this principle would lead to a better understanding of the "residual chlorine" test and its significance in water treatment. In particular it would indicate the importance of the time factor, which is often disregarded in current discussion of the water treatment process. In sewage treatment this time relation is of great economic importance, since it calls for a balancing between the cost of storage and the cost of chemicals in such a way that local conditions may frequently determine the economic rate of chlorine application.

Another general principle of chlorination, best illustrated in sewage practice, is the specific action of chlorine as a toxic agent in distinction from its action of chlorine as a toxic agent in distinction from its action as an oxidizing agent. Reference has already been made to the selective action of chlorine for bacteria as compared with organic matter in general. It has been shown that the two simultaneous but independent reactions, the germicidal and the oxidizing, have different concentration exponents, and this and other facts may be utilized to suppress the wasteful oxidizing reaction and obtain the maximum benefit from the germicidal reaction. In water works the cost of the chlorine is a negligible amount in comparison with the total cost of water delivered to the consumer, and economy is not a factor to be considered. In sewage disinfection the cost

may run into a good many dollars per million gallons, this cost being largely for chlorine. Any possible economy, therefore, is well worth while.

FLOW OF WATER THROUGH CULVERTS

Bulletin No. 1, Studies in Engineering, University of Iowa, presents the results of 3,301 experiments on the flow of water through short conduits such as pipe and box culverts and sluiceways under levees. The experiments were conducted by the Bureau of Public Roads, U. S. Department of Agriculture, and the State University of Iowa, Iowa City, at the University hydraulic laboratory.

The investigations were undertaken primarily for the purpose of determining:

1. The quantity of water that will flow through culverts or sluiceways under levees of different materials, sizes, and shapes under conditions of actual use.
2. What conditions tend to increase or decrease such quantity.
3. What principles should be followed in design to secure the greatest discharging capacity for the least cost.

The report describes the methods of making the tests and presents the experimental results together with the discharge formulas developed for the various culverts. (The formulas are omitted in this article.)

Summary and Conclusions

The following conclusions are drawn from the results of 1,480 experiments on pipe culverts made of concrete, vitrified-clay, and corrugated-metal, of the following sizes: 12, 18, 24 and 30 in. in diameter; and 1,821 tests on concrete box culverts of the following sizes: 2-ft. by 2-ft., 3-ft. by 3-ft., 4-ft. by 4-ft., 4-ft. by 3-ft., 4-ft. by 2¼-ft., 4-ft. by 2-ft., 4-ft. by 1-ft., and 4-ft. by ½-ft.

Tests were made on the culverts flowing partly full and full, both with a free and submerged outlet. Experiments were also run with various types of entrances.

The discharging capacity of a culvert depends primarily upon the cross-section of the culvert and the difference in water level at the two ends of the culvert.

To obtain the maximum discharge the culvert must be so laid as to insure the full cross-section of the culvert being filled by the flowing water.

If the culvert is laid at too high an elevation with respect to the water levels at the two ends, it will not run full and hence will not attain its maximum capacity.

If a culvert is so laid that both its upstream and downstream ends are completely submerged the amount of water which it discharges will be proportional to the square root of the difference in water level at the two ends; and the exact grade at which the culvert is laid has no effect whatever upon its maximum discharging capacity.

The difference in water level at the two ends, called hereafter the head on the culvert, is utilized in three ways: first, in overcoming friction around the entrance corner; second, in overcoming friction along the walls throughout the barrel of the culvert; third, in imparting the velocity necessary to the water in entering the culvert. The three portions into which the total head is thus divided are called for convenience, entrance loss, friction loss, and velocity head, respectively.

The following general conclusions are drawn from the results of the tests on the pipe culverts:

The coefficient of roughness, n in the Kutter formula for the concrete pipe ranges from 0.012 for the 12 in. size to 0.013 for the 30-in. size.

The coefficient of roughness, n, in the Kutter formula, for the vitrified-clay pipe ranges from 0.010 for the 12-in. size to 0.013 for the 30-in. size.

The coefficient of roughness, n, in the Kutter formula, for the corrugated-metal pipe ranges from 0.019 for the 12-in. size to 0.023 for the 30-in. size.

In concrete, vitrified-clay, and corrugated-metal pipe, culverts, 30.6 ft. long, with straight endwall entrances:

a. The 12-in. concrete pipe with beveled lip end upstream discharges about 49 per cent more water than the 12-in. metal pipe.

b. The 18-in. concrete pipe with beveled lip end upstream discharges about 40 per cent more water than the 18-in. metal pipe.

c. The 24-in. concrete pipe with beveled lip end upstream discharges about 36 per cent more water than the 24-in. metal pipe.

d. The 30-in. concrete pipe with beveled lip end upstream discharges about 32 per cent more water than the 30-in. metal pipe.

e. The 12-in. clay pipe discharges about 65 per cent more water than the 12-in. metal pipe.

f. The 18-in. clay pipe discharges about 50 per cent more water than the 18-in. metal pipe.

g. The 24-in. clay pipe discharges about 40 per cent more water than the 24-in. metal pipe.

h. The 30-in. clay pipe discharges about 30 per cent more water than the 30-in. metal pipe.

The relative capacities of these culverts may also be expressed in the following terms which are mathematically equivalent to the above.

i. The 12-in. metal pipe has about 67 per cent of the carrying capacity of the 12-in. concrete pipe with beveled lip end upstream.

j. The 18-in. metal pipe has about 71 per cent of the carrying capacity of the 18-in. concrete pipe with beveled lip end upstream.

k. The 24-in. metal pipe has about 74 per cent of the carrying capacity of the 24-in. concrete pipe with beveled lip end upstream.

l. The 30-in. metal pipe has about 76 per cent of the carrying capacity of the 30-in. concrete pipe with beveled lip end upstream.

m. The 12-in. metal pipe has about 61 per cent of the carrying capacity of the 12-in. clay pipe.

n. The 18-in. metal pipe has about 68 per cent of the carrying capacity of the 18-in. clay pipe.

o. The 24-in. metal pipe has about 73 per cent of the carrying capacity of the 24-in. clay pipe.

p. The 30-in. metal pipe has about 78 per cent of the carrying capacity of the 30-in. clay pipe.

In concrete pipe culverts, 30.6 ft. long, with straight endwall entrances.

a. The 12-in. pipe with beveled lip end upstream discharges about 5 per cent more water than the same pipe with a square cornered entrance.

b. The 18-in. pipe with beveled lip end upstream discharges about 9 per cent more water than the same pipe with a square cornered entrance.

c. The 24-in. pipe with beveled lip end upstream discharges about 12 per cent more water than the same pipe with a square cornered entrance.

d. The 30-in. pipe with beveled lip end upstream discharges about 14 per cent more water than the same pipe with a square cornered entrance.

Due to the larger amount of pipe friction in corrugated-metal pipes, a change in culvert length produces a greater change in discharge than with concrete and vitrified pipe culverts.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert increase the capacity from 1 to 10 per cent over that obtained in a metal pipe culvert with a straight endwall.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert are more efficient when set flush with the edge of the pipe than when set 6 in. back from the edge of the pipe.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert are more efficient when built full height to the top of the headwall than when constructed only to the standard height.

The 45-degree wingwalls used in connection with a vitrified-clay pipe culvert produce a carrying capacity substantially equal to that with the regular bell end upstream.

The U-type wingwalls used in connection with a vitrified-clay pipe culvert produce a carrying capacity slightly less than that with the straight endwall.

The beveled lip end at the entrance of a concrete pipe culvert is a great aid in reducing the entrance loss, especially in the larger sizes.

The bell end at the entrance of a vitrified-clay pipe culvert by virtue of its shape greatly reduces the entrance loss below that produced by a right-angle corner, especially in the smaller sizes.

A 24-in. clay pipe, 38 ft. long, with a straight endwall and the regular bell-end upstream carries about 10 per cent more water than the same culvert with a square cornered entrance.

Merely rounding the entrance to a 24-in. vitrified-clay pipe culvert increases the capacity approximately 13 per cent over that obtained with a square cornered entrance.

By projecting the pipe through the headwall so as to obtain the effect on the discharge of no headwall, it was found that:

a. In the 12-in. concrete pipe culvert having a square cornered entrance, there is little difference whether the pipe projected 3 in., 2 ft., or 4 ft. beyond the headwall.

b. The discharge is decreased slightly

by projecting the pipe through the headwall as compared with the same culvert with a straight endwall entrance.

c. The 18-in. corrugated-metal pipe culvert with a 3-in. projection beyond the headwall carries slightly more water than the same pipe with either a 2 ft. or a 4 ft. projection.

d. The 18-in. metal pipe culvert with a straight endwall entrance carries more water than the same pipe with any length of projection.

By doubling the area of the outlet end of an 18-in. vitrified-clay pipe culvert by attaching a conical section, the sides of which diverge at an angle of about 10 degrees, the discharge of the culvert, when the outlet end is submerged, is increased about 40 per cent over that obtained through the same culvert having a uniform bore throughout.

The following general conclusions are drawn from the results of the tests on the concrete box culverts:

Concrete box culverts with straight headwalls and rounded lip entrance discharge from 8 to 12 per cent more water than the same size culvert with square cornered entrance in the sizes tested in this investigation.

Concrete box culverts with straight headwalls and beveled lip entrance discharge from 7 to 9 per cent more water than the same size culvert with square cornered entrance in the sizes tested in this investigation.

If the outlet end of a 36-ft. box culvert with a rounded lip entrance is flared by diverging the sides at an angle of 60 degree 30 ft. throughout a distance of 10 to 12 ft. from the outlet headwall, thus doubling the area of its cross-section at the outlet, the capacity of the culvert is increased about 60 per cent above the capacity of a similar culvert 36 ft. long with the uniform bore extending the entire length of the culvert.

The 2-ft. by 2-ft. box culvert, 30 ft. long, with a rounded lip entrance and flared on the two sides for its entire length to a 4-ft. by 2-ft. opening at the outlet end will discharge 86 per cent more water than a 2-ft. by 2-ft. by 30-ft. box culvert of uniform bore with a square cornered entrance, when both culverts are flowing full.

The 2-ft. by 2-ft. box culvert, 30 ft. long, with a rounded lip entrance and flared on the two sides for its entire length to a 4-ft. by 2-ft. opening at the outlet end will discharge the same quantity of water as a 3.61-ft. by 2-ft. by 30-ft. box culvert of uniform bore with a square cornered entrance, when both culverts are flowing full.

Rectangular concrete box culverts require more head to overcome friction than square concrete box culverts of the same area, and hence have a smaller carrying capacity provided the entrance losses (in head) are the same. The head lost in friction for culverts of the same area varies inversely with the hydraulic radius. The entrance losses, however, on the rectangular culverts tested are less than those on the square culverts of the same area and type of entrance. Since one culvert differs from another in capacity per square foot of area inversely in proportion to the square foot of the sum of all head losses involved, it is possible for a rectangular culvert to have a slightly greater capacity than a square culvert, although the reverse is usually the case.

The chamfering of the corners of box culverts reduces the discharge of the culvert by an insignificant amount, an amount which is less in per cent than the corresponding reduction in culvert area produced by the chamfering.

A comparison of the results of the tests on the concrete box culverts with the results of the tests on the pipe culverts reveals the following facts:

A 24-in. concrete pipe culvert, 30 ft. long, with beveled lip end upstream, carries 19 per cent less water than a 2-ft. by 2-ft. by 30-ft. concrete box culvert with square cornered entrance (when the two culverts are flowing full), but the concrete pipe culvert carries about 7 per cent more water per square foot of waterway than the box culvert.

A 24-in. corrugated-metal pipe culvert, 30 ft. long, carries 57 per cent less water than a 2-ft. by 2- ft. by 30-ft. box culvert with square cornered entrance (when the two culverts are flowing full), and the metal pipe carries about 23 per cent less water per square foot of waterway than the box culvert.

A 27-in. vitrified-clay pipe culvert, 30 ft. long, (containing approximately the same cross-sectional area as a 2-ft. by 2-ft. box culvert) will carry 7 per cent more water than the 2-ft. by 2-ft. by 30-ft. box culvert with square cornered entrance, when both culverts are flowing full.

The value of the entrance loss coefficient for a given type of entrance corner

varies with the shape of the cross-section of the culvert. That cross-section having the greatest hydraulic radius for a given culvert area has also the greatest entrance loss coefficient. That is, the entrance loss coefficient is greater for a circular culvert than for one with a square section, and the coefficient for the square section is greater than that for the rectangular section.

The results on the various types of entrances and outlets have an an important bearing on the design of suction and discharge pipes for drainage and irrigation pumping plants. Sluiceways under levees are hydraulically like road culverts. The data in this report will likewise be found directly applicable to many irrigation structures.

WELDED PIPE LINE CONSTRUCTION, OAKLAND, CALIF.

By John B. Abell, 637 Union Trust Bldg., Cleveland, Ohio.

Work on the new 90 mile, Stable-Arc welded water supply line for the City of Oakland, California, has progressed to the point where the most skeptical now admit that the new process for fabrication of the steel pipe is certain to revolutionize the entire scheme of production for this field in the very near future, according to J. F. Lincoln, vice-president of the Lincoln Electric Company of Cleveland, Ohio.

More than five miles of the Stable-Arc welded steel pipe has already been laid in the trenches for this tremendous undertaking which is to bring the entire water supply for Oakland from the Mokelumne River. In addition each day sees vast quantities of the 65 in. diameter pipe of 30 ft. lengths, fabricated by the eight specially designed Lincoln Electric Company automatic welders at the West Berkeley, California, plant of the Steel Tank and Pipe Company.

Accurate costs being kept on the fabrication of the Stable-Arc welded pipe already manufactured, provide ample evidence of the economies possible through the use of the new process. Known costs, it is said, on work already done, provide complete justification for the three million dollar saving which has been guaranteed by the Steel Tank and Pipe Company on the fabrication of the 90 miles of pipe, as against the estimate for supplying either lock-bar or riveted pipe.

The tremendous savings being made possible by the use of the Stable-Arc process, result from reduced labor costs and a substantial decrease in the amount of steel required for the pipes. Due to the fact that it has been found possible with the Stable-Arc to provide practically 100 per cent connections and joints, and thus have a strength equal to the steel itself, the quantity of steel involved in the pipe has been materially reduced as against that which would have been required for other methods of construction where extra heavy steel plate is necessary to compensate for the weakness of the connections.

Important as it is, the fact that Stable-Arc welding has enabled the manufacturers to insure a 35 per cent reduction of the fabricating costs for the Oakland pipe job as against that which would have prevailed had the older methods been pursued, this is by no means the entire explanation of the inevitable revolution which will take place in the pipe-making field as a result of the application of this Lincoln process.

Of vital importance is the fact that the welded pipe is all being put through tests far beyond those which could be stood by pipe employing any other known joining method. Subjected to these tests, each 30 ft. length has come through without failure or damage.

Using steel plate furnished by the Newport News Ship Building and Dry Dock Company and varying in thickness from $\frac{3}{8}$ to $\frac{5}{8}$ in., the Steel Tank and Pipe Company in the West Berkeley plant runs the pieces through the straightening rolls, breaking rolls and bending rolls to form it into shape.

After the two half circular pieces have been tacked together by hand welding, they are then put through the specially built Lincoln automatic welders where the joining of the steel members is completed. This step finished the pipe lengths are sent to the testing machines.

In the case of the half inch pipe, the 30 ft. sections are carried up to a pressure of 312 lbs. per sq. in., which gives about 21,500 lbs. fibre stress in the steel. While under this pressure, each pipe section is sledged on every foot of the weld with a 19 lb. hammer.

Following this procedure, the pressure is increased to 400 lbs. per square inch, which represents the elastic limit of the

steel itself and in fact it has been found the steel in the pipe stretches sufficiently so that the circumference increases from 1 to 2 in.

Only after having successfully passed this test without developing any leaks, is the Stable-Arc welded pipe passed through the final treatment. The sections after having been thus treated, are dipped in bitumastic, then wrapped with a protective covering and put in the trenches.

As the fabrication of the pipe for this 90 mile undertaking progresses, sections are taken at random from those passing through the shop and subjected to a variety of other tests, any one of which it is said, could not be withstood by pipe made through the lock-bar or riveted method.

After having subjected a number of sections to tension of 45,000 lbs. per sq. in., these same lengths were then bent to a 90 degree angle. Here again, the tests showed the ability of the welded connections to withstand extreme abuse, for they came through in an entirely satisfactory manner.

Among other severe tests to which sections of the Stable-Arc welded steel pipe for the Oakland job, have been put was one which consisted of collapsing the pipe under extreme pressure. Examination of the sections which had been put through this test showed that the Stable-Arc welds had come through without failure.

All along the line, from the time the fabrication of the pipe was started, the welded connections have purposely been put through tests which it was definitely known could not have been stood by sections in which the older joining methods were employed. Entirely establishing its superior strength, the welded product not only of the Lincoln Electric Company and the Steel Tank and Pipe Company, but also to those of the East Bay Municipal District, under whose direction the project is being carried forward.

Early in March the first sections of the Stable-Arc welded steel pipe were laid in the trenches and hand welded together. Since that date additional sections have been laid with increasing rapidity and at a speed of progress which is establishing a new record for this sort of project.

It is upon the known facts as to the economy of the Stable-Arc welded steel pipe, the proven superior strength of the product and the ease and speed of fabrication, that those close to the industry are predicting the early and entire replacement of lock bar or riveted pipe by the welded product such as is being used on the Oakland undertaking.

ZEOLITE WATER SOFTENERS FOR DOMESTIC USE

By W. C. Hirn and E. F. Eldridge, Michigan Department of Health, Lansing, Mich.

A large proportion of the public and private water supplies of the state contain considerable amounts of calcium and magnesium in solution, which are minerals that cause hardness. When water containing these minerals is used for washing purposes soap combines with them and forms a sticky curd. Very little benefit is gained by using soap in hard water until enough has been used to combine with the calcium and magnesium salts, or as is commonly stated, to soften the water. After this soap begins forming a lather and is effective as a cleansing agent, but the disagreeable curdy material is still left to form a film over everything that has been washed and permeate fabrics, making them rough and harsh for drying.

When hard water is heated much of the calcium and magnesium become insoluble, precipitate out of solution and settle on the inner walls of the heating vessel forming a scale. This scale retards heat penetration through the walls and finally destroys the heating appliance through over heating or by completely closing the water passages.

An estimate of the expense of using a hard water for domestic purposes is given in a pamphlet issued by the Michigan Department of Health entitled "Municipal Water Softening." This pamphlet may be had on request to the Department.

All natural water contains many elements besides calcium and magnesium, but these are responsible for the disagreeable feature known as hardness and to soften water it is necessary to remove them. This can be done by precipitating these substances in tanks provided for this purpose by means of heat or chemical treatment or by bringing the water in contact with an exchange silicate containing sodium which will be exchanged for calcium and magnesium. The sodium will not form a curd when it

comes in contact with soap nor will it form a scale on the walls of heating appliances.

History of Zeolites

The term Zeolite will be used in this article to designate any medium with base exchange properties used in water softening. Technically this is a broad use of the term but this article is written for general distribution and general usage appears to have adopted the term zeolite for materials having this property.

About 75 years ago an English chemist discovered that when a liquid extract of barnyard manure containing ammonia was filtered through a layer of loamy soil the soluble ammonia, together with other impurities was taken up by the soil. This lead to a series of experiments to determine the constituent of the soil responsible for retaining the ammonia. After a long series of experiments it was found that a double silicate formed from sodium aluminate and sodium silicate possessed the power of taking up ammonia and other substances including sodium, calcium and magnesium. A few years later another English chemist discovered that these double silicates under certain conditions would exchange one of these substances for another and that this exchange could be repeated an indefinite number of times when proper conditions were met.

These chemists were engaged in agricultural chemistry and naturally were attempting to use this exchange properly in conjunction with soil fertilization which did not prove to be practicable. Later an attempt was made to utilize it in the process of manufacturing beet sugar but without marked success.

Composition and Source of Zeolites

The chemical composition of zeolites is somewhat indefinite but may be given approximately as 2 SiO_2, Al_2O_3, Na_2O, + 6 H_2O. Artificially it can be made by fusing together feldspar, kaolin, silica and sodium carbonate in proper proportions. After rehydrating and washing, this material contains about 46 per cent silica, 22 per cent alumina, 13.6 per cent sodium oxide and 18.4 per cent water.

The largest deposits of natural zeolites in the United States used for water softening occur in New Jersey, Delaware and Maryland. This deposit, known to geologists as greensands, covers an area of hundreds of square miles near or at the surface and has a depth of from a few feet to as much as 30 ft. This material is not suitable for use as a water softening medium in its natural state but is processed to remove impurities, to make the grains harder and tougher and to increase its exchange capacity. When prepared for use it has the appearance of rather fine sand of a greenish or brown color.

At the present time there are several manufacturers producing artificial zeolites made by different methods and others processing natural zeolites. Both the natural and artificial materials have been used successfully and in some instances both have failed to give satisfactory service because of faulty preparation. The purchaser must depend upon the reliability of the firm from which the softener is purchased for assurance that it will be successful and permanent.

Chemistry of Water Softening by Means of Zeolites

When hard water is passed through a bed of zeolite which has been prepared for water softening purposes the calcium and magnesium in the water are exchanged for the sodium in the zeolite bed. This exchange will continue until all of the usable sodium has been removed from the zeolite. The water leaving the softener will then contain sodium bicarbonate(baking soda) and sodium sulfate (Glauber's salts) instead of calcium and magnesium bicarbonate and sulfate. The softened water contains as much mineral as before softening but the soap curd and scale forming minerals have been removed and replaced by harmless substances.

After the sodium in the zeolite is exhausted it can be replaced readily by bringing a concentrated solution of sodium salts in contact with the zeolite. The easiest and cheapest method of accomplishing this is by means of a solution of sodium chloride (common salt). When the concentrated solution of sodium chloride comes in contact with the zeolite the sodium is exchanged for calcium and magnesium, and these combine with the chloride forming calcium and magnesium chloride. These are washed out of the softener in the regenerating process.

The zeolites now used for water softening are nearly all prepared so that the reconditioning process takes only a short time and for household softeners the entire reconditioning process can be accomplished in less than an hour.

If all of the sodium in a salt solution could be made available for reconditioning the zeolite it would require but 1.95 lbs. of salt to soften 1,000 gals. of water with a hardness of 200 parts per million (11.7 gr. per gal). The exchange of sodium for calcium, however, is not accomplished except in the presence of a concentrated solution of sodium salts which requires that considerable salt must be wasted.

Most zeolite softeners are now sold under a stipulation that not more than ½ lb. of salt will be required to remove 1,000 grains of hardness from water. This amounts to 5.85 lbs. of salt for softening 1,000 gals. of water with a hardness of 200 per million.

Water that is excessively hard is often more difficult to soften by the base exchange process than water near or below the average hardness of Michigan public water supplies which is about 280 parts per million or 16.3 grains per gallon. When the purchase of a zeolite softener is under consideration the mineral constituents in the water to be softened should be ascertained and if the hardness is greater than 340 parts per million (about 20 grains per gal.) special allowances for capacity and treatment must be considered, especially if sodium salts and iron are present.

The average family of five persons when supplied with a plentiful supply of clean soft water will use probably 500 gals. per week. Salt for use in water softeners purchased in 100 lb. bags costs about one cent per pound, making the cost of salt for softening a week's supply of water approximately three cents. The interest, depreciation and repair cost of a household softener of ample size for the average faimly should amount to no more than similar charges for a rain water cistern and soft water pumps. As water from a zeolite softener is softer than cistern water the saving in soap will probably more than compensate for the cost of salt for reconditioning.

Mechanical Arrangements

To insure satisfactory operation and low cost for maintenance the parts of a Zeolite water softener must be of substantial construction and so far as possible all valves and fitting should be easily replaceable and of standard design.

The tank containing the softening medium should be made of a good grade of steel or other suitable metal of substantial thickness. It should be of proper dimensions to permit the use of the required depth of zeolite with a liberal allowance left for a layer of gravel beneath the zeolite to promote good distribution of wash water and liberal space above the zeolite to prevent its being washed away during the washing or agitation process. The sum of these dimensions requires that the tank be at least 4½ ft. deep and with some type of zeolites considerably more depth must be provided.

The shell of the tank should be well reinforced at the hand hole opening which needs to be of liberal size with a substantial hand hole cover. Openings where pipe connections are made to the tank should also be well reinforced.

The bottom of the tank must be provided with an arrangement for distributing water evenly over the entire bottom area to insure even distribution of water for washing and agitating the zeolite bed and with ample inlet and outlet pipes to allow a liberal use of flushing water for agitation to prevent sections of the zeolite bed from hardening.

The salt should be introduced into the zeolite bed in a concentrated solution and any salt container or "salt pot" arrangement which will meet this requirement will prove satisfactory. The salt container should be of ample size to hold the amount of salt required at each recharging and must be constructed of good steel or other material which will resist the corrosive action of salt. It should be conveniently located for introducing the salt and provided with an opening of convenient size with a substantial water tight cover where salt is added.

The softening medium cannot operate above a certain rate which requires that if perfectly soft water is needed at rapid rates at certain times, the maximum rate will determine the size of softener required and should be given careful attention when the size and type of appliance is considered.

Water introduced into a zeolite softener should be clear and free from suspended particles. Dirt particles will become stranded in the zeolite bed and obstruct the flow of water, interfere with the softening process and may tend to cement the zeolite particles into solid masses. When dirty water must be treated a filter should be intalled preceding the softener.

PROPORTIONING CONCRETE BY WATER CEMENT RATIO

By W. C. Mabee, Assistant Chief Engineer, Indianapolis Water Co., Indianapolis, Ind.

(A paper presented before the Indiana Section of the American Water Works Association, March 25, 1926.)

We have been so long accustomed to seeing concrete flowing down chutes with a sea of water floating it along that it appeared somewhat revolutionary to be told that this procedure was all wrong. We had believed that the quantity of cement employed was the governing factor in proportioning concrete for strength and paid little or no regard to the quantity of water used. Whereas we now learn that we were drowning our concrete and wasting cement without getting the added strength which the added cement was supposed to contribute. It was somewhat of a shock to learn that the given strength could be obtained with less cement, by simply reducing the quantity of water, or, in other words, by changing the water-cement ratio.

In fact, we had given little or no consideration to the amount of water being used; as long as we kept our proportion of cement to aggregate constant, we were quite sure we had done all that was necessary to secure a uniform product.

We now learn that the strength of concrete is absolutely fixed by the water-ratio, with the aggregate acting merely as a filler, so to speak, to simply add bulk to the cement paste or glue, and that any water in excess of that required to hydrate the cement and produce a workable mix of concrete reduces its strength. The ratio of water to cement called the "water-ratio theory" was developed as a result of research work with concrete materials at the laboratories of the Lewis Institute, Chicago, co-operating with the Portland Cement Association.

It has long been known that the size and grading of aggregate affect the strength of concrete, but it remained for these experiments to demonstrate that the influence of these factors was controlled largely by the effect they had upon the quantity of water used in the mix. It was found that the higher the ratio of water used the weaker concrete would be, without regard particularly to the quantity of coarse and fine aggregate employed.

As a measure of this strength, the slump test was devised and while the slump test is not an accurate indication of concrete strength it is the best index yet found.

The concrete giving the least slump or the driest workable mix, indicates the greatest strength and the most economical use of the materials entering into the concrete; but the degree of plasticity or workability, as it is called, must ever be suited to the character of the work in hand.

It is now possible for the engineers to proportion concrete by calculation, the potential strength being fixed by the water-cement ratio, influenced in the mix by the grading of coarse and fine aggregates and the workability of the concrete.

The actual or final strength of the concrete so calculated is affected by its age, the length of time in mixing, the method of curing, the temperature during which it was made and cured and the degree of impurities in the aggregate.

Methods of field control have been devised, the purpose of which is uniformity of product and dependability of results; this involves tests for quality and cleanliness of aggregates, percentage of moisture in the aggregates and the bulking resulting from this moisture and the determination of the grading, expressed in percentages of the coarse and fine aggregates by sieve analysis. All of these field tests have been rendered quite simple and can readily be made by an intelligent inspector on the job.

Many of our larger contractors are now proportioning and testing their concrete in this manner and are having their inspectors and field engineers report daily analysis of aggregate, make slump tests from samples of concrete actually going into the work and are even having compression tests made in laboratories from cylinders prepared from these samples.

In this manner a careful record is kept to guide them in designing and maintaining concrete mixes of uniform strength.

Along with the scientific proportioning of concrete and the advance in the art, there is a growing tendency among structural designers to use higher working stresses for bar steel in reinforced concrete. Factors based upon ultimate strength have given way to "Margins of Strength" based upon the yield point or service strength of steel. Values of 18,000 or even 20,000 lbs. per sq. in. are

now considered as amply conservative by many leading authorities in place of the time honored stress of 16,000 lbs. per sq. in.

We also observe the tendency among engineers to require more exacting tests upon the materials which enter into concrete, and we find them insisting upon batch mixers equipped with water measuring devices, and timing devices and such refinements as inundators, all of which tends toward producing a more dependable and uniform product.

There is now much more coring of pavements and laboratory testing of specimens than formerly. Engineers are now able to calculate the strength of concrete with assurance that the results will be within reasonable prescribed limits. To the engineer engaged in water works practice, one of the most vital considerations is impermeability. He is chiefly concerned in producing concrete of such density that it is impervious to water, and he knows that the degree of water tightness will depend upon the richness of the mix in cement, the suitability of the aggregates, the quantity of water used and the care with which the concrete is placed in the forms. Much depends upon the puddling or churning of the concrete in the forms as it is being deposited, if honeycomb pockets of aggregate are to be avoided, and he is well aware of the fact that an excess of water seriously affects permeability of concrete.

In work of any magnitude, consideration must be given to the control of cracks in concrete structures due to the forces of expansion and contraction, which cracks will occur regardless of the strength or impermeability of the concrete. These cracks can be localized and made water-tight by the insertion of suitable metal baffles or cut-off plates at certain intervals or in the day joints, or they can be quite effectively distributed by the use of sufficient steel bars uniformly placed in the faces of the work, using keyways in adjoining sections and coating the joinings with rich mortar, after having cleaned them thoroughly. The writer employes 4/10 of 1 per cent for this purpose.

Thin sections of concrete require a richer concrete than do heavier ones. Plastering as a medium for waterproofing is a dubious expedient and in the writer's opinion should not be resorted to as a general practice, although there may be exceptions. It will be found more economical to proportion the concrete richer in cement and dispense with the plaster; it is false economy to skimp in the use of cement in structures designed to hold water.

The important consideration in the design of concrete for uniform impermeability as for uniform strength is not so much in the grading of the aggregates as it is in the fixing of the proper water-cement ratio and holding that ratio constant even to the extent of taking into the consideration the moisture in the aggregates, then adding good sound coarse and fine aggregate in sufficient quantity to make the resultant mix work smoothly and flow freely into the forms and around the reinforcing bars, applying sufficient agitation to insure positive distribution of all the materials.

The consideration of next importance is the proper timing of the mixing, from 1½ to 2 minutes is good practice, and finally the protection and care of the finished product; by this is meant keeping the concrete moist for a week or ten days to avoid evaporation of the mixing water and consequent loss of strength. It has been found that proper attention to this detail alone increases the strength of concrete 65 per cent.

Floors can be kept damp by covering with sand and wetting frequently, vertical surfaces by draping burlap or canvas over the walls and sprinkling with a hose several times a day. Flat slab reservoir construction can be flooded to a depth of an inch or so by placing a slight ridge of mortar around the margin of the day's work. This is very effective in the hot dry days of midsummer, when such work is usually done. Checking and cracking of the surface is also reduced to a minimum by this expedient.

A little longer time in mixing pays big dividends in strength, in impermeability and in workability. Speeding up the mixer in the hope of increasing the output may actually produce negative results.

Increasing the time of mixing from one minute to two minutes will yield an increase of strength of 10 per cent and one to five will give 15 per cent.

One of the most interesting facts developed by students of concrete phenomena is that the strength of concrete increases as the logarithm of its age.

The writer only recently had occasion to cut into concrete that he had seen built over twenty years ago and it cer-

tainly showed every indication of having increased in strength.

In conclusion, it can be said that the engineers of Indiana are becoming more and more familiar with the method of proportioning concrete by the "water-cement ratio" theory and are putting this knowledge into their daily practice.

Their slogan should be: "Less water in mixing—more water in curing."

The following discussion of Mr. Mabee's paper is by Mr. J. W. Kelly, of the Portland Cement Association, Chicago:

Practical use has been made of the water cement ratio on almost one hundred concrete jobs. These range in size from small structures to public highways, large bridges and dam. It has been found that the proper water ratio for any strength and quality of concrete desired can be obtained by simple methods not radically different from our past practice on concrete work.

The three things entering into a concrete mix which are under the control of the mixer operator are, (1) the relative richness of the mix, or amount of cement, (2) the relative coarseness of the aggregate, or the proportion of pebbles to sand, and (3) the relative plasticity of the mix or what is more usually termed the workability. Each of these influences the amount of water required to obtain the plastic mix demanded by placing, finishing, etc. The above water requirements can be readily determined and the concrete proportions expressed in terms convenient to the man at the mixer.

The effort as regards strength is to use richer mixes, minimum amounts of sand, and drier mixtures, since these tend toward stronger concrete. The effort from a standpoint of economy, however, is to use lean mixes, since aggregates cost less than cement. For concrete of the same strength, leaner mixes can be obtained by using minimum amounts of sand and by using drier mixtures as before. The proper balance of these three factors constitutes the design of a mix.

One point that must not be overlooked in designing for concrete of certain compressive strengths is the waterproofness of the concrete. Richer mixes are required for waterproofness than may be called for by strength requirements above. This can be met by designing concretes of higher strength; it being usually considered that concretes of 3,000 pounds strength or better are waterproof.

Practical men want to know (1) how much cement to use, (2) how much sand is the best proportion to the pebbles, and (3) how dry can the mixture be and still work into place satisfactorily.

There are two methods of arriving at the proportions desired. One is by direct trial, using different proportions (but keeping the same water ratio) and judging by eye or by test which combination gives the best mix. Intelligently handled, this is a satisfactory method of proportioning concrete; otherwise it is little better than our arbitrary schemes of the past.

The method of calculating the ideal proportions for any job has been simplified until it calls for only a little study and a very little arithmetic. This method is described in a booklet published by the Portland Cement Association entitled, "Design and Control of Concrete Mixtures." Briefly, the method is as follows:

1. The strength desired and the allowable plasticity of concrete are decided upon for the job under consideration.

2. From a chart prepared by the Structural Materials Research Laboratory and based on the experience of many thousands of tests, the amounts of cement and of "mixed" aggregate are taken; this determines the mix.

3. Small samples of the sand and pebbles are passed through a set of sieves, and the relative coarseness of the particles of each determined by a simple calculation. This enables us to calculate the percentage of sand which must be employed to give us the ideal grading of "mixed" aggregate.

4. When the percentage of sand is known, the "mixed" aggregate can be expressed in terms of the separate aggregates, i. e., sand and pebbles.

5. Since the foregoing measurements have been made on samples which have been dried to obtain uniform results, the proportions obtained above must be corrected for the bulking effect of moisture. This involves measuring the water in a sample of each aggregate as it normally comes to the work, and determining the relation between a cubic foot of dry aggregate and an equal amount of the damp material.

These calculations enable the man at the mixer to measure definitely the proper amounts of cement, sand, and pebbles and know he is getting the proper water ratio and strength.

The strength of concrete as originally

proportioned may be maintained on the job even if the aggregates change as the job progresses. Occasional tests for water in the aggregate enable us to compensate for variations in bulking. Occasional sieve tests detect any considerable changes in the grading of the aggregate, and the proportions may be corrected accordingly. The workability of the concrete is regulated by the slump test, a simple field test which gives us a relatively good idea of the water used in the mixture.

Water-ratio proportioning of concrete has proven so simple and practical that it is being generally adopted for all classes of work. The advantage of knowing definitely what kind of concrete we are getting, and knowing that the most economical proportions are being used, have outweighed our natural reluctance to adopt new ideas.

USE OF LIME IN CONSTRUCTION

By J. S. Elwell, Manager Construction Department, National Lime Association.

(From paper before 1926 convention of National Lime Association.)

Stucco, plaster, mortar and concrete are the general divisions of construction into which lime enters, and a few of its advantages in each will be briefly presented.

Stucco

Stucco is fundamentally a covering to conceal and protect whatever method of construction is used. It must be composed of materials which withstand all weather conditions, and the proof that lime stucco meets this requirement is its universal use. The excessively wet climate of England has not affected it in hundreds of years. Germany knew no other stucco in the past and does not today. In hot, dry Mexico lime stucco is used exclusively today just as it was generations ago. The long cold winters of New England do not bother the lime stucco that has stood there for many years.

Lime stucco is adaptable to any type of construction from the small house to the largest office building, as demonstrated by its use on the sesquicentennial buildings at Philadelphia and on the fourteen story office building in San Francisco.

Also it is just as satisfactory on frame construction as it is on masonry; in fact, it is often applied to both backings on the same building. On properly furred metal or wire lath lime will accommodate itself to the inevitable settling and shrinking of frame buildings. The gradual hardening of lime over a considerable time avoids cracking on any acceptable construction.

The first or scratch coat is mixed somewhat rich in lime and with the proper amount of hair or fibre. It is applied as a heavy coat with sufficient pressure to give a firm key back of the lath. The pressure the plasterer must exert with lime stucco is less than with substitutes.

The first application is deeply scratched to give the best possible bond for the next coat. It is customary to allow the scratch to dry out for several days so that the stucco will develop its shrinkage and the building take the load. When all coats of a quick setting stucco are put on in quick succession the settlement caused by the weight of the stucco added to its shrinkage may cause unsightly cracks.

With lime the building is given time to gradually adjust itself while the three coats are being applied. There is no danger in rapid completion of a lime job after the first coat is partly set. The last two coats being light in weight and lean in cementing material are not subject to much shrinkage.

The addition of some gauging material is advocated and it may have some advantages, but many feel the use of too much will destroy the gradual adjustment of lime stucco.

The ease with which lime is worked is probably its best known property, and nowhere is this advantage more in evidence than in the stucco finishes. Any desired effect of color or texture is obtainable, and uniformity is assured for the plasterer is not hurried as when using a quick setting material.

In general, all large builders who have made a study of the economy and durability of stuccos are led straight to lime. This is true in Philadelphia, Columbus, and Minneapolis and there is no reason why a more general understanding of the problem would not increase the field. Lime is the original stucco material.

Plaster

No use of lime is more important than interior plastering. Everyone knows that lime is used for plaster, but few have any conception of the fundamental difference between plasters. The rust resist-

ing, fire retarding and sound insulating properties of lime plaster have been swamped in the flood of propaganda that has been put out in the last 20 years.

Whether wood lath or metal lath are used, the durability of plaster is dependent on the action of that plaster on metal. If the metal lath or the nails in the wood lath are not protected from corrosion, the plaster is liable to failure and occupancy of a building may be actually hazardous.

It has long been known that lime prevents rust, and in recent tests run at the Rock Island arsenal it was shown that corrosion was absolutely prevented by lime, while rusting had started on similar specimens exposed to air. Specimens tested in another commercial plaster were found to have "corrosion well developed."

Microphotographs show clearly that on the specimen exposed to moist air, rust had started to spread from the impurities in the steel. The surface of the metal tested in the other plaster was very dark and proves conclusively that this material attacks metal when moisture is present. It is well known that corrosion once started never stops. Under the same conditions lime prevented the start of corrosion and if it does not start it will never cause a failure in a ceiling.

It is very important that plaster be a fire retardant. Fire departments are given the right of way over all other traffic in order that they may get to the fire before it has had time to spread. If that fire can be confined inside the room where it starts just a few moments longer by some certain plaster, that plaster will prevent many serious fires. Few conflagrations spring forth full grown, for almost every fire is small at the start and it is only the ones that are not confined that are serious.

Many tests have been made with plasters under extreme fire conditions, but no comparative tests have been made to show their relative merits in the average starting fire. In—and perhaps thanks to—the absence of laboratory tests with the smaller fires, we must fall back on the practical experience of fire fighters for this information. Among the several fire chiefs that have stated their experience, Chief Alexander Henderson, of Kansas City, Mo., has best put their opinion, writing: "My experience has been that in buildings containing lime plaster, fires were more easily confined to their place of origin."

Next, consider acoustics. We have control over our eyes so that we need not see anything we wish to avoid, but our ears receive sounds whether we wish to hear them or not. This shortcoming makes it very important that our partitions be good insulators of sound.

The relative merits of different wall plasters in respect to sound are very difficult to fix. We can see two lights at the same time and easily tell which is the brightest, but we cannot be in two rooms at once and sense which is the quietest.

The fact that buildings plastered with lime plaster were quieter and more restful has long been known, but the full degree of difference between plasters has not been realized.

Recently, one phase of the problem of acoustics was investigated by the Bureau of Standards. Laboratory tests were made on many plasters to determine the extent to which sound would penetrate. Eight of the panels tested contained lime only and the tests show that in every case the transmission of sound was lowest with straight lime plaster.

In only three cases was direct comparison made between gypsum and lime and the results show that actual sound penetrates hard plasters with 6 to 24 times the volume that it penetrates lime plaster.

These figures are only a measure of the transmission of sound from one room to another. They do not touch on absorption and reflection which govern the acoustics within a room. The value of lime plaster in insuring a quiet room or building is well established by experience.

The application of lime plaster has been made to appear very difficult and expensive. This is due largely to the fact that the true facts regarding its use have been submerged.

The detailed work of plastering with lime need not be discussed except to bring out the fact that the best of keys—on which the strength of all plaster depends—are obtained. Another fact with lime plaster which is not realized is that the brown may be immediately laid on the wall over the scratch coat.

Plastering a ceiling—where metal lath is now the standard—is a simple operation with lime. The scratch coat is put on rapidly and easily, and it is followed immediately with the brown coat. If

properly haired absolutely no difficulty is experienced with plaster falling off.

Attention should be called to the choice of metal lath. It is always desirable to choose a lath that presents the greatest bearing surface for the plaster. The best wall lath is not always suitable for ceiling work. A certain lath may carry wall plaster perfectly, but when this same lath is put on a ceiling—the bearing surface may be so reduced that the plaster will not stay in place. A little thought and study of this detail will go far to improve plastering in general.

Passing up the usual involved arguments and falling back on practical experience, the simple facts remain that lime plaster does not destroy but rather preserves the metal that always holds it in place; it retards the spread of a fire, and insulates against sound better than any other plaster. The largest builders in the country use it for its economy, durability and ease of application. Lime plaster is suitable and also necessary for the finest work.

Mortar

The general public knows lime as something used to stick bricks together, and they are probably correct in that no brick or stone mortars are successfully used, unless they contain lime. In the struggle for business much pressure is brought to bear to show the necessity of adding something to lime mortar. On the other hand, certain patent mortars that advertise "no lime needed" are known to add the lime in their plant, which makes the advertisement true. It may be necessary to adulterate lime mortar to keep certain competitive industries solvent, but it is not necessary for the sake of the mortar itself.

Independence Hall—over 150 years old—tells the story of durability just as well as going back to Babylon. The question of strength required is answered by considering that any modern house or apartment seldom has walls over five stories high. Modern office buildings, with their great height, do not depend on their masonry for strength, but rather carry their walls story by story on steel or concrete frames.

Even at the age of one day, tests at the Rock Island arsenal prove that lime mortar does not show appreciable settlement at loads far above anything met in practice.

The West Baden Springs (Ind.) Hotel boasts of the largest dome in the world, with a span of 200 ft., or 12 ft. larger than St. Peter's Cathedral in Rome. This dome supported on 16 brick piers is laid up in straight lime mortar without any added cement.

Concrete

The fact that lime is added to concrete by the biggest men in the construction industry is bound to raise the question as to why they do it.

Colonel Cooper specified its use in the Wilson Dam at Muscle Shoals, and it is specified in all government work under the direction of the Chief of Engineers, U. S. Army. There is good and sufficient reason why such men insist that concrete on which they stake their reputations shall be as good in the forms as it came out of the mixer. Lime acts as a lubricant, facilitating placing and at the same time preventing the stone and grout from becoming unmixed on the trip from the mixer to the form. It insures an easier placed and more uniform concrete, which accounts for the watertightness and the greater strength of lime concrete.

Caution says that "lime does not weaken concrete," but that is only a small part of the story. Structural or building concrete is generally difficult to work into the forms on account of small sections and heavy or complex reinforcing. Workability, or the ability of concrete to be worked into place, is obtained by adding either water or lime. Excess water reduces the strength while lime does not. It follows logically that if the required workability is obtained by lime and the amount of excess water is reduced, the concrete will be stronger. Field specimens prove that the use of lime does result in stronger structural concrete and friends of lime need not apologize for that fact.

The greater uniformity of concrete placed by the lime method is the direct and logical result of being able to move the concrete into place in the same condition that it left the mixer. Here again the specimens taken from jobs justify the use of lime because the designer is sure that there is no weak concrete at the critical points.

The improved appearance of lime concrete is also the result of its uniformity and workability.

We would naturally expect that the Chicago Plan Commission would use the most economical and dependable method of watertightening the pits of their bridges over the Chicago River. Their letter on the subject says: "Ten pounds

of hydrated lime per bag of cement was specified and used. The counterweight pits of all these bridges have proven to be absolutely watertight." At the Wells Street bridge it is 34 ft. from the water line to the bottom of the pits and they tell us these pits are absolutely dry. There is no mysterious property in lime that water-tightens concrete, it is just that uniform, dense concrete is watertight.

All concrete, and even good concrete, will in time weather or disintegrate. Considerable study has been put on this subject in the last few years, and it has been found that temperature and moisture changes are the major causes. Investigations have shown that the stresses due to alternate wetting and drying may be five or six times as great as the greatest temperature stresses. Professor H. A. LaRue of Missouri University has stated that the moisture stresses in concrete are reduced to one-twelfth or over one-twentieth, by the use of lime. Considering that these two forces may act in the same or opposite directions, it can be demonstrated that the tendency to disintegration with lime is only 12% to 25% of what it is in plain concrete. If we take frost action into consideration the advantage of lime concrete is greater than ever.

Concrete products are materially improved by lime. Recent plant-runs that were tested at the Rock Island arsenal prove that the addition of 20% or more of lime makes concrete blocks watertight, as well as stronger. Cinder blocks are manufactured cheaper and better with lime.

John H. McClatchy, of Philadelphia, builds homes on a large scale. He sells these homes on time payments, that run over a period of twenty years. Mr. McClatchy is naturally interested in first cost as well as durability. He finds it most satisfactory to use gauged lime stucco, lime plaster, lime mortar and lime in his concrete. The study his organization must have given these subjects and the results he obtains leave no room for doubt.

PAVING BRICK SHIPMENTS

Increases in production, shipments and unfilled orders with a corresponding decline in stock-on-hand is reported by the paving brick industry to the United States Department of Commerce for June as compared with May.

Production went from 21,103,000 in May to 26,342,000 in June. Shipments went from 22,645,000 in May to 30,312,000 in June. Stock fell from 123,808,000 in May to 115,971,000 in June. Unfilled orders climbed from 71,430,000 the first day of May to 75,283,000 the first day of June.

These figures are compiled from the reports of 26 companies representing 76 per cent of the normal tonnage of the industry.

Ohio leads the list in consumption for June with 8,685,000. Kansas was next with 3,700,000, Texas third with 3,198,000 and Illinois fourth with 2,446,000.

AIR DRYING OF SEWAGE SLUDGE ON GLASS COVERED SAND BEDS

By Floyd G. Browne and Frank Woodbury Jones

(Editor's Note: Mr. Browne is Superintendent of the Sewage Treatment Works, at Marion, Ohio. Mr. Jones is Sanitary Chemist with George B. Gascoigne, Consulting Sanitary Engineer, Cleveland, Ohio. They presented the following paper at the 1926 meeting of the New Jersey Sewage Works Association.)

An effective and satisfactory method of disposing of the sludge which is produced in sewage treatment is an essential feature of works for such treatment. Indeed, a sewage treatment process may be considered successful only to the extent that the sludge problem has been solved. This paper aims to present some results of experience with glass-covered drying beds. Beds of this type were first tried and developed at the Cleveland, Ohio, Testing Station in 1912, and several have since been installed.

It is not necessary in this paper, to dwell upon the varieties and the characteristics of sewage sludges. Briefly, we may mention green sludge from plain sedimentation; sludge digested to different degrees of ripeness in septic tanks, two-story or Imhoff tanks and in separate digestion tanks, and sludge from the activated sludge process. Each of these sludges is peculiar to its class and requires particular methods for its treatment. Here, however, we are concerned with the digested sludge such as is obtained from the ordinary two-story tank, and it will be understood that the discus-

sion applies to this produce as usually obtained and treated in northern climates.

Air Drying of Sludge

The most excellent paper given by Mr. Cavett last year makes unnecessary at this point, a detailed description of the methods employed for air drying of sludge. It is sufficient to say that three general methods are in use.

Open Fields—In some places it is possible to pump the digested sludge either into pits or to open fields either to dry out naturally or else to be plowed in as fertilizer. This method, while satisfactory from a disposal standpoint, may be open to the serious objection of unsightliness, particularly where the sludge is not covered with earth. Usually the open field method is one more of expediency rather than good practice.

Open Sand Beds—The most general practiced method for the air drying of sludge is on open sand beds. These sand beds are usually artificially prepared and provided with good underdrainage. A great deal of study has been given to the proper kind of bed construction, yet we believe in the last analysis it is more the character of the sludge than of the drying bed which determines the efficacy of drying both as to time required and quality of cake produced.

Covered Beds—In many sewage treatment plants, it has been found that one of the serious drawbacks to good operation was lack of sludge drying area. Consequently, in many instances it has been necessary to devise ways and means for getting rid of the sludge which often times resulted in objectionable conditions around the plant or else has worked a hardship upon the settling tanks because of inability to draw the sludge when necessary. Furthermore, weather conditions frequently are such that the drying of sludge is almost impossible. When this occurs during the warm weather, it constitutes a very serious handicap in the operation of the settling tanks. Consequently, in 1912 and 1913, when the sewage testing station at Cleveland was in operation, the drying of sludge under glass was attempted with a view in the first place, to cutting down the area required, and in the second place, making the drying independent of the weather. The results obtained in these experiments were so promising that municipal plants built shortly after at Alliance and Canton, Ohio, included glass-covered sludge drying beds. The drying beds themselves are constructed similar to the open beds, but in such a way that they can be covered with standard greenhouse construction permitting ventilation and ready accessibility with industrial track and dump car.

Examples of glass covered sludge drying beds now in service are at Canton, Alliance and Marion, Ohio; Highland Park, Ill.; and Boonton, N. J. It is our understanding that others are contemplated in the near future.

Results to be Expected from Drying Beds

The object of drying sludge is to reduce the moisture content to such a degree that the sludge can be easily removed from the sand and transported readily to a point of ultimate disposal where it can be either utilized as fertilizer or stored in piles. This means that the dried sludge must be readily handleable, that is, the moisture content must be low enough to permit the sludge to be removed in cakes which will hang together. Soupy or mushy sludge is not handleable, irrespective of its moisture content. The character of the wet sludge has a great deal to do with its behavior when applied to drying beds. A granular sludge with high solids content will dry and drain much more rapidly than will a pasty sludge of equal solid content. Furthermore, there is a wide variation in the per cent of solids found in wet digested sludge. The solids content may vary from as low as 5 per cent to as high as 18 per cent or even more. There seems to be no unanimity of opinion as to what may be considered a satisfactory sludge cake for removal. We have heard it stated that sludge can be applied to a bed and be removed in three days. This, no doubt, is true, but such statements as a rule do not include the moisture content of the sludge applied nor the depth to which it was placed upon the bed. Generally speaking, sludge with a solids content of between 30 and 40 or, if you please, a moisture content of between 70 and 60, may be considered a satisfactory sludge for removal. Any sludge with a greater moisture content is questionable, that is, as regards its ease of handling. Consequently, for the purpose of this discussion, we will consider that for good operation, a sludge should be reduced to approximately 65 per cent moisture before being considered removable. Any further reduction of moisture is just that much gain, for the drier the cake

the less weight to be moved and the more easy it is to be handled.

Results with Open and Covered Beds Compared

The efficacy of a sludge drying area may be measured in two ways. First, how much sludge can be handled in a year, and second, how quickly will it dry. It is obvious that on an open bed the drying of sludge is dependent upon weather conditions. Furthermore, we know that when digested sludge containing large quantities of gas is placed upon an open bed and immediately thereafter a rain occurs, the gas is beaten out, the sludge loses much of its buoyancy and consequently becomes a more compact, or less porous mass. This obviously will require a longer time to reach a removable condition.

In the next place, winter drying of sludge in this climate on open beds is practically out of the question, due not only to the freezing, but also to the fact that once snow falls the beds are out of commission until the snow disappears and the beds are dried out.

In the plants at Schenectady, N. Y., Fitchburg, Mass., and Plainfield, N. J., we have fair examples of what can be accomplished in the air drying of sludge on open beds. There are other places at which the data may be just as complete which perhaps would tell a different story, but with these we are not so familiar. At Marion, Ohio, during the past year, we have had an opportunity to observe the operation of glass-covered beds, and an attempt will be made to show possibilities in each case. Furthermore, some data are available for the past four years, concerning the operation of the glass-covered sludge beds at Alliance, Ohio.

We might digress at this point to speak of the information we get at Alliance, or rather, the lack of information we have there, which illustrates how particularly essential it is, if you please, to have some good operating data. We know how much sludge is taken up by the beds, how much in a manner is going on them, but not enough to know what is really being accomplished there with the sludge in the matter of treatment.

During the past five years at Plainfield, there have been treated on open sludge drying beds, totalling some 18,040 sq. ft., approximately 4,000 cu. yds. of wet sludge per year, and the number of dryings has amounted to not more than seven per season.

The solids in the wet sludge have varied from 5.5 to 7.5 per cent. We believe that this represents the maximum possible usage of the available sludge bed area at this plant.

At Fitchburg during the past 10 years, there has been treated on 18,315 sq. ft. of sludge drying area an average of 3,334 cu. yds. of wet sludge or 343.5 tons of dry solids. This does not represent all the sludge produced at the plant. About six dryings per year is all that have been possible, some years only five. The sludge has contained a yearly average of from 8.41 to 16.94 per cent of solids, averaging for the ten years 13.00 per cent. The sludge as removed had yearly averages varying from 43.10 to 63.99 per cent solids, averaging 51.97 per cent. The depth of application was from 10 to 12 ins. or more.

At Schenectady the records show that during the past year, 1,862 cu. yds. of dried sludge have been removed from some 24,320 sq. ft. of sludge drying area. No data are given as to the number of times the beds were used but apparently the area has been adequate. Data on the old beds show as many as ten fillings and as few as seven per year, depending upon the weather. The sludge was thin and applied to a depth of 8 to 10 ins.

The results at Plainfield and at Fitchburg indicate the possibility of drying 0.22 and 0.176 cu. yds. of wet sludge per year per square foot of drying area, respectively. Plainfield data indicate, however, the disposal of only about 250 tons of dry solids per year or 0.014 tons per square foot, whereas at Fitchburg, the average has been approximately 350 tons, or 0.019 tons per sq. ft. per year. It is to be mentioned, however, that the variation from year to year was considerable due to weather conditions.

At Schenectady, an experiment was conducted during September and early October, 1925, to determine the rate of drying on open beds. Sludge was applied on different beds to depths averaging 6, 8, 10 and 12 ins. The results indicate that 6 ins. of a 95 per cent moisture sludge can dry to 65 per cent moisture in 5 days, 8 ins. of 96 per cent in 7 days, 10 ins. of 94 per cent in 12 days and 12 ins. of 94 per cent in 18 days, of summer temperatures between 78° Fahrenheit and 36° Fahrenheit with light winds and practically no precipitation.

Experiments conducted at Marion, Ohio, at various times during the past year on glass-covered beds, indicate that

6 ins. of 92 per cent moisture sludge can be dried to 65 per cent moisture in 4 days, 8 ins. of 94 to 91 per cent in 9 days, and 10 and 12 ins. of 93 per cent in about 15 days.

It was noted that on both open and closed beds, the greatest reduction in moisture occurred in the first 24 hours, which tends to show that subsequent reductions are more the effect of evaporation than of drainage.

At Alliance, Ohio, using glass-covered sludge drying beds with a partially digested sludge of rather poor quality, the following results were obtained on 10,240 sq. ft. of drying area, dosed to an average depth of 6 ins.:

	Cu. yds. Wet Sludge Applied	Number of Fillings
1920	2,525	14
1921	3,560	23
1922	3,015	19.5
1923	2,910	19.5
Average	3,000	19.0

This shows that there have been an average of 19 fillings a year and that the beds can be used practically all the year round.

At Marion during the past year, 2,500 cu. yds. of wet sludge averaging 7.5 per cent solids or 92.5 per cent moisture, were applied to the drying beds in 10 pumpings. The drying beds have not been utilized to their maximum extent, due to the fact that means for transporting the sludge were not always available when required. The sludge as removed from the beds had a solids content varying between 97 and 27, averaging 50 per cent. If the beds had been cleaned when the sludge was first ready for removal, the data indicate that the actual time necessary to dry the 2,500 cu. yds. to a satisfactory removable condition would not have exceeded 120 days at the most. This indicates further, that 7,800 cu. yds. of wet sludge averaging 7.5 per cent solids could be dried to at least 35 per cent solids or 65 per cent moisture in one year on 12,580 sq. ft. of drying area or about 0.60 cu. yd. per sq. ft. per year. On this basis each square foot of covered sludge drying area can dispose of at least three times the volume of sludge dried on open beds. Or, in other words, for a given plant, only one-third the open bed area is required if the beds are covered.

The Optimum Depth to Apply Wet Sludge

It is obvious that the less the depth of wet sludge the more quickly it will dry. However, it is equally obvious that if sludge be applied too shallow the available drying area will be used up without getting rid of very much sludge. Furthermore, practically just as much sand will be taken away with a thin cake as with one somewhat thicker, and the man hours required to remove a thin cake are almost as high as for the removal of a thick cake. Therefore, it is necessary to determine at each plant the depth to which the sludge produced can be most economically and effectively applied. This means that the sludge should be applied to such a depth that it will produce a fairly thick cake and at the same time dry to such a point that it can be readily handled on removal, thus making the bed available for the necessary wet sludge from the tanks to maintain a proper working balance. In other words, the sludge beds should be so operated that the digested sludge from the tanks can be taken care of when necessary to assure their efficient operation. This optimum depth will usually be found to be between 12 and 8 ins., probably about 10 ins. In a covered bed where conditions can be somewhat controlled, this optimum depth can be more readily determined.

The Area of Sand Beds Required

In the earlier installations of sludge beds, the area allowed amounted to perhaps about 1-2 sq. ft. per person. It is now generally recognized that in most cases this figure is too low and present designs for open sludge beds usually make an allowance of from 0.75 to 1.00 sq. ft. per person, the latter figure being preferable. In the covered sludge drying beds it is realized that less area is required, and judging from the possibilities indicated by results obtained at Marion and elsewhere, the figure of about 1-3 sq. ft. per person seems justified. It is realized of course, that the amount of sludge to be handled at any particular installation will depend on the concentration of the sewage to be treated and also upon the reduction effected by digestion. Usually a well digested sludge should not amount to more than 1,000 gals. or 5 cu. yds. per million gallons of sewage treated. In some instances it is true that this figure is exceeded while in others it has been less.

Relative Cost of Open and Covered Sludge Drying Beds

The cost of sludge drying beds will depend upon the cost of sand in any par-

ticular locality. For the actual drying space whether open or covered, the cost per unit area should be the same. The cost of covering may be stated, judging from actual construction, to be approximately $1.60 per sq. ft., while the cost of the sand beds, including industrial track, is approximately $1.00 per sq. ft. Consequently, if the area of covered beds can be made 1-3 that of open beds, it is seen that the net cost per capita is less for covered beds.

Besides the construction cost there is to be considered the maintenance cost. The question arises as to the possibilities of breakage of glass. During the past year the upkeep of the Marion plant has been practically nothing, and we are informed that at Alliance during the past 5 years the damage has been relatively small. It is conceivable that with hail and tornadoes the damage may be very large. However, these matters can be covered by insurance at relatively a nominal cost. Taking all factors into consideration, the total annual costs of both types may be taken as being on a par with the advantage, if any, in favor of the covered beds.

Advantages of Covered Beds

The greenhouse covered sludge beds have several distinctive advantages. In the first place, there is the matter of compactness. It has been stated that the area required for covered beds is 1-3, or less, of that required for open beds. This means that the entire working space is spread over a relatively small area. Furthermore, engineers and city officials are now stressing the advantages of maintaining sewage treatment works in such a manner that they will be attractive to the eye. A greenhouse covered sludge drying bed in this respect is particularly favorable.

The real criterion of how much sludge bed area you need depends upon how much area you need to get rid of a pound of dried solids. About two years ago we were called in to rescue a sewage plant which was said to be on its last legs in a little bit of a town. There was a great deal of agitation about this plant, particularly from a farmer who had a pasture bordering on the stream into which the effluent discharged. One of the first recommendations for this plant was to clean it up. There was nothing wrong in the design of the plant and it seemed adequate for the purposes, so we managed to get hold of a fellow who would take an interest and he painted the buildings, trimmed up the dikes, kept the banks clean, and got the old sludge that had piled up and hauled it away, and I have been told that the fellow who knocked the plant the hardest is now one of its boosters, simply because the plant now appears to be well taken care of.

As indicated above, the cost of a covered sludge drying bed, all things considered, may be estimated as being either less or at least on a par with that of open beds.

The greatest advantage of the glass-covered sludge bed, however, is the fact that its operation is relatively independent of weather conditions. This applies not so much because it is possible to operate the beds during the colder months, as to the fact that during the summer, when it is necessary or at least desirable to get rid of large quantities of sludge, that regular schedules can be maintained since, except for humidity, the wet weather will not affect the drying. Most of us know that it is very discouraging to have all of our available sludge bed area filled up with nicely digested sludge only to have a 24 hour rain beat it down into a compact, soggy mass. With covered beds such rains are caught on the roof and pass off into the gutters, while the sludge remains unaffected. Then, too, the temperature inside a covered bed is considerably higher than in the open air, and there is no disadvantage due to lack of ventilation. In winter the temperature inside is usually 15 to 25 degrees higher than outside, so that freezing of the sludge is relatively slight. While the length of time for drying is longer in winter than in summer, it is entirely feasible.

Conclusions

The drying of sludge on prepared sand beds is an accepted and established process in sewage treatment. Where these beds are built in the open, usefulness is often impaired due to unfavorable weather conditions. Furthermore, since it is desirable to maintain so far as possible, regular schedules in all processes of sewage treatment, an attempt should be made to make this applicable to the drying of sludge. This has been done by covering the sludge drying beds with greenhouse construction, thus shutting out the rain and conserving natural heat during the colder months of the year. This has resulted, we believe, in making possible an increase in the drying of sludge from about 6 or 7 applications at

the most, to as many as 20 per year. And not only can glass-covered sludge beds be operated during the summer months, but practically throughout the year.

PRACTICAL APPLICATION OF NEW JERSEY SEWAGE EXPERIMENTS

By Weston Gavett and Richard H. Gould

(Editor's Note: The practical applications of the findings of the New Jersey sewage experiment station are described in the following paper which was read at the 1926 meeting of the New Jersey Sewage Works Association.)

At a meeting of the members of the research committee of the New Jersey Sewage Works Association last October we were asked to act as an informal committee to co-operate with the sewage experiment station, particularly along the lines of furnishing suggestions along engineering lines and in helping guide the course of research toward the solution of problems of practical importance. We have been unable as yet to offer any suggestions that in our opinion would improve upon the program now being worked out so satisfactorily by the experiment station. We have, however, through becoming better acquainted with the work, been greatly impressed with the importance of the work and the excellent practical results being obtained. It is most unfortunate that the members of this association do not have the opportunity of talking these matters over directly with Dr. Rudolfs and thus have the benefit of his enthusiasm and clarity of thought and expression in bringing out the various points involved.

It was thought, however, that you might be interested in getting our reaction on the results accomplished by the experiment station as they apply to practical matters of design and operation. This is the excuse for the brief remarks that follow.

The members of the association all have a practical knowledge of the art of sewage disposal and know from bitter experience many of the difficulties that are concerned with the operations of sewage works. The development of sewage disposal is in many ways analogous to other industrial developments. Advances have been made largely through more or less accidental discovery and development rather than upon theory worked out carefully in advance. We have all heard the story of how the first satisfactory rubber compound was discovered by accident after long and fruitless investigation. The accidental dropping of certain ingredients on a hot stove produced a rubber compound of the quality desired. The tremendous development of the modern rubber industry goes back to the analysis and working out of the compounds and treatment received by this bit of rubber that was accidentally dropped.

Certain developments in sewage disposal today are about in the stage of this small particle of rubber. By certain more or less accidental discoveries, guided it is true, by extremely intelligent selection and application, we now have devices which will separate sewage solids from the liquid and digest them in an inoffensive manner to inert material. Unfortunately, good results such as mentioned above are not always obtained. The great discrepancy between the amount of sludge capacity required in different Imhoff tank installations is an illustration. We know of one plant, not in this locality, where satisfactory results are obtained with a digestion capacity of less than one half cubic foot per capita of connected population. There are other plants with many times this capacity where results are most unsatisfactory.

Along the lines of progress in these matters, engineers and operators have recognized the possible economic advantages in getting away from the deep and expensive construction required by the Imhoff tank, in certain cases, by utilizing shallower tanks and the digestion of sludge in tanks separated from the sedimentation compartments. In so doing, however, certain environmental conditions in the digestion tanks are altered and we are faced with uncertainties as to just what the results will be. Until recently our knowledge of the bio-chemical activities of digestion and the exact effect of environmental conditions has been limited. Part of the work of the experimental station has been to delve into these matters and to determine the effect of the various influences. This can only be done by painstaking and carefully worked out scientific research. The advances made to date are most gratifying and the future prospects look bright.

It is not our intention to cover the whole field in which the station has been working. You are already familiar with many of the practical findings, such as

the methods developed for the drying of poorly conditioned sludge and the treatment of scum. Obviously, the first job before the investigators was to take a census of the organisms found throughout the plant. This has been a long, tedious job and has taken up a large part of the time spent to date. It would be impossible and useless to tag every organism in the plant. The main groups that seemed to be active and useful nave been determined. An interesting feature of the investigation of the tank population was the discovery of the relation of protozoa to tank behavior. When these small animals start to increase, trouble is ahead and their numbers are reduced when the tank is restored to proper condition. With the census taking completed, more specific work with greater possibilities for practical application could be taken up.

Along the lines of sludge digestion, the research work has brought out that any particle of sludge material on entering a tank must go through a certain cycle in its progress of decomposition to an inoffensive end product. Fresh solids, of given concentration allowed to digest without being seeded with ripe sludge, required about ninety days to ripen. When seeded with ripe sludge, the fresh solids passed through the cycle faster and ripened in about thirty days. These results were obtained at a temperature of approximately 70 degrees F. All fresh solids have to pass through the same cycle whether seeded or not. In the first stages certain acid products are given off, and later on, other products which will tend to neutralize acid conditions. The first stages of digestion are accompanied by noxious odors. A practical illustration of this fact was noted at a settling tank where odor had been reported. The sludge in the tanks was black and inodorous, but a pronounced odor was found on opening the cover over the inlet channel. Here the obviously fresh solids, deposited from the incoming sewage, were going through the early stages of digestion. This channel with less than 1/1000 th. of the volume of the tanks was causing the odor. The obvious answer is for the engineer to eliminate such places as far as possible in his design and for the operator to keep any fresh solid catchers flushed at frequent intervals.

It has further been found that the character of the products and the efficiency of digestion varies very considerably with the acidity of the medium in the tank. If it is too acid, poor digestion takes place and offensive products are given off and resulting physical conditions, such as the boiling of the sludge, are particularly troublesome and expensive to handle. Similiar undesirable results are evident should the tank become too alkaline. By the work of the station the best degree of acidity has been established. This makes it possible, by the judicious application of lime or some other suitable substance, to control to a considerable extent, the activities in the digestion chamber. Under normal conditions, when the capacity of the tank is not exceeded, the acid products are counter-balanced by the alkaline products coming from a later period in the digestion, and no difficulty ensues. Should the access of fresh solids be greatly increased, the acid production will be correspondingly increased without a sufficient volume of the older and alkaline producing sludge being present to maintain the proper relation. The proper reaction of the sludge has been found with values for the Hydrogen-ion concentration between pH 7.3—7.6. The use of the term pH need not frighten the operator who is not a chemist. For practical purposes, the determination of the reaction, requires only the matching of the color obtained by adding the proper dye.

From many experiments it has been worked out that for the reasons given above a digestion tank, under favorable temperature conditions, should not be called upon to care for more than 2% of fresh solids daily. This is on the basis of dry solids. For example, if a sewage has a solid content of 0.1500 lbs. of dry solids per capita per day (70 gms. per capita) there must be in the tank fifty times this amount, or 7.5 lbs. of dry solids. If the sludge contains 95% moisture, the total weight of sludge would be 150 lbs., or a volume of 2.4 cu. ft. per capita. If the sludge contains 90% moisture, the required volume would be only 1.2 cu. ft. per capita. It has also been brought out, however, that by the judicious application of lime, a greater quantity of dry solids may be handled successfully, thus increasing the effective capacity of the tanks. Too much lime should not be added, the proper amount being determined by the reactions given above.

The questions of the limitation of the dosage of a digestion chamber with fresh solids and the possibilities of intensive

action by chemical control have an extremely important bearing on the design of new works and in the control of old works, perhaps overloaded and producing unsatisfactory results. It should be mentioned in passing that absolute figures for the amount of the fresh solids that may be handled should be used with caution and due consideration be taken of temperature conditions and other points to be brought out later. Members of the association as a whole can be of great service in helping to establish definite practical limits for the quantities involved now that the trail is blazed for them and the lines along which it is best to work are pointed out.

Another most important consideration developed is that the best digestion cannot be secured unless certain poisonous products that result from decomposition are removed from the digestion chamber. In the best operating Imhoff tanks, this is apparently accomplished by diffusion through the slots or by the inter-changes that take place between the sedimentation and digestion compartments caused by slight fluctuations in the water surface level in the tank. The research work has brought out certain information that will tend to show about what volume of flow is required through the digestion chamber to get rid of these poisonous products. This has a distinct application in design and operation of separate digestion tanks that are not connected with flowing sewage and where no automatic provision for the removal of toxins is present.

The question of whether to stir or not to stir digesting sludge has been investigated. It has been found that occasional stirring, about once a week, is better than no stirring or too frequent stirring.

The studies that have been made along the lines of temperature as affecting the rate of digestion are of the greatest importance. The rates at which digestion takes place at different temperatures are being established and are pretty well worked out at the present time. With these factors known, the problem of obtaining the best digestion results as far as temperature is concerned becomes one of engineering and economics. This matter has great possibilities. It for example, may prove economical by the proper attention to thermal losses to permit the maintenance of such temperatures in digestion tanks throughout the year as to permit material construction savings. Given fundamental data, most problems are easy of solution. Without such data, chances of error are great.

An interesting finding is that the numbers of digestive bacteria do not increase in proportion to the concentration of the solids. It is stated that the maximum number does not consistently exceed sixty million per cc. For example, we could not expect double the number of bacteria in a 90% sludge as in the same volume of 95% sludge even though the dry solids bear that relation.

Data of great interest have been found on the relation of air to digesting sludge. Liquification of solids was found at a maximum with air excluded, while the addition of air stimulated gas production. This consideration opens up a question in the practice of sewage disposal. Do we want to collect and utilize gases to the greatest extent possible, or do we prefer to liquify this organic material and flow it down stream? The lines along which control in this matter may be had is pointed out.

We have touched briefly on the above concrete results of the research work in connection with sludge digestion because they appeal to us as being of most immediate practical value. It has been stated that the problem of sewage disposal is the problem of sludge disposal and this statement made some time ago is essentially true today. We have all followed with interest the intensive efforts that have been made in the treatment of the sludge produced from the activated sludge process of sewage disposal. While inoffensive disposal is secured in several cases, the cost of the disposal and the complications of control and equipment in many cases will oftentimes more than counter-balance the many advantages of this process of disposal. The application of the digestion process to the treatment of the sludge has been proposed and gives promise of successful application in certain cases. The extension of our knowledge of digestion processes as a result of the work of the Experiment Station is most timely and seems to have an ever widening field of application.

We do not wish to convey the impression that important problems and expenses are not attached to sewage disposal other than that of sludge treatment. They do seem, however, to be better controlled and the results more reliable. The station has done much important work in connection with sprinkling filters in investigating the animal

and bacterial life in the filters and in methods for their control. This work is important. Methods have been developed through chemical control by which it is possible to regulate the growth of protozoa which constitute some of the higher forms of microscopic life in the filters. These protozoa constitute largely the effective film on the stones of the sprinkling filter and by their control it is possible to regulate the thickness of this film. While these matters are still being studied, it seems that the best results can be obtained by controlling the depth of this film. The major points involved are the effectiveness of nitrification taking place, the prevention of clogging of the filters, and possibly also the very important question of fly control. It is probable that by controlling the depth of film in which the fly larva can breed a practical control of the fly can be established. This consideration explains perhaps the reason why the filter fly at some plants is absent or of no appreciable consequence, whereas at other places, much difficulty is met from this source.

It would be possible to go on at some length along similar lines and speak of such questions as the oxygen demand of sludges and other allied matters that are under investigation at the Experiment Station. It may be better, however, to stop with the above brief enumeration of some of the actual accomplishments. In this we will be following the precedent so well established by the Experiment Station in not bursting into print with speculative and unsubstantial material. The spirit of research so well exemplified at the Station permits only the publication of facts as they are found by carefully controlled experiments. It may be said though that while the accomplishments to date have been very material, the program that is now being followed at the Station is expected to bring to light additional knowledge of the most useful nature.

ECONOMY OF DIESEL ENGINE POWER

Diesel engines offer such an unusual opportunity to reduce power costs in almost every industry that a new thirty-two page bulletin, "Economy of Diesel Engine Power," issued by Fairbanks, Morse & Company of Chicago, is of timely interest. The bulletin takes up an analysis of the various factors which affect the cost of power, such as fuel cost, operating labor, maintenance, first cost and fixed charges, reliability and simplicity. The costs of a typical small Diesel power plant are analyzed and compared with similar costs for a steam plant.

Other interesting chapters cover such points as the cost of purchased power, layout of the Diesel plant and the question of the fuel oil supply. Interwoven through this semi-technical story is a discussion of the application of Diesels in a wide variety of industries together with illustrations of Diesel equipped plants.

This book should be in the library of everyone who is interested in power, whether that interest be in connection with a small power problem or whether it be for a large power plant. The bulletin will be sent without charge on request to the company at their Chicago office.

MODIFIED EARTH ROADS IN KANSAS

By W. A. Stacey, County Engineer, Hutchinson, Kansas.

(Editor's Note: The following article tells of a method of applying thin layers of sand or gravel to earth roads, and is from a paper read at the Southwest Road School in 1926.)

The development of any state road system, or for that matter, any county system, is gradual. From a strictly economical standpoint, what you spend on a road should be governed by the traffic on it or the traffic you expect to be on it immediately that it is improved. In most cases, however, funds are limited and mileages are large, consequently the quality of the road must often lag behind the demands that the traffic is making of it.

The grading and draining of the road is, of course, to be followed by the establishment of a patrol system of maintenance. Thereafter you may note that a minor portion of your road is very difficult to maintain and is the cause of nearly all of your traffic troubles. Assuming that by reason of light traffic or lack of funds, paving is not contemplated in the near future of this road, then the next step in development should be the modification of the earth surface by some material that will allow the road

to be maintained properly and give service to the traffic.

Materials Used as Modifiers

The modifiers usually are: For clay roads, sand or gravel; for sand roads, sand-clay or clay-gravel. Given proper drainage and the proper modification of the top surface, the earth road is enabled to carry satisfactorily a much heavier traffic than was previously possible.

This modification of the earth surface to bring about the sanded wearing surface may be produced by construction alone or may be produced hand in hand with the regular maintenance of the road. By the later method I mean the application of thin layers of sand or gravel on the clay surface and working it into that surface with the assistance of the traffic.

The development by either method of the sanded surface is, I believe, a common and standard practice in almost every place where there is material to produce it with. Our neighboring states of Colorado and Nebraska, have many miles of it. Likewise, many states in the south are relying on some form of it for the improvement of parts of their state systems.

Some counties in Kansas have a considerable mileage of some type of the sand and gravel surface: Allen, Anderson, Cherokee, Labette, Montgomery and Wilson having let federal aid contracts for such work as early as 1919-20, followed more recently by some of the more western counties.

Method of Constructing Sanded Surface

I will outline our experience in Reno County with the production of the sanded surface on earth roads. Beginning about 10 years ago, fairly steady progress has since been made in increasing the mileage of this surface on the county system. For the reason that all our share of the federal aid money has been put on paving and bridges, this light surfacing has been done as county or state aid projects.

The material to produce this surface is obtained locally from two sources:

1. Pit run sand testing 5-20 per cent on a ¼-in. screen is found in the bed and valley of the Arkansas River and several creeks in the north half of the county.

2. Outcrops of sand with a clay binder are found in the hills of Permian formation in the south half of the county. The binder varies from 3-20 per cent and the sand alone tests about 10-15 per cent on a ¼-in. screen.

As you may infer, in the latter case it is simply a strip and load proposition; whereas in the former case it is usually necessary to pump the sand out in a stock pile and allow it to dry out before it can be used. A 6-in. sand pump and a tractor are used to get the sand out and the cost of products is ordinarily 35-40 ct. per cubic yard. Sometimes we own the pit and sometimes we pay the owner a royalty of 10 ct. per cubic yard removed.

Disregarding some 10 or 12 miles of county road where natural sand-clay is taken from the ditches by heavy blade grading, the surfacing work in this county is divided as follows:

1. Treatment of clay roads.
2. Treatment and sand roads.

The sand put on clay roads is ordinarily clean or contains very little binder. We expect the road to furnish the binder. The usual practice is that the road is graded or has been graded to a uniform width and crown on an established center line. The surface of the road should be firm and smooth before surfacing is applied. The sand is placed at the rate of 400-450 cu. yds. per mile on a roadway of 28 ft. if the road has never been treated before, and 300-350 cu. yds. per mile if it has been sanded before. As soon as dumped on the road, the sand is spread by the patrolman with his grader over the surface. When so spread, there is not much inconvenience to the traffic and after the second rain, if the patrolman has been diligent, the bulk of the sand has worked into the crust of the road, leaving usually just enough on top to cushion the surface and make maintenance easy. If the grade and drainage of the road were good when the sand went on, and the patrolman is careful to prevent loss of material into the side ditches, we ordinarily do not find it necessary to renew the surfacing for 2 or 3 years. This is especially true if care is taken during ditch cleaning with a tractor to avoid spreading an excess of soil on the roadway. It is often stated that the best way to sand a road is to windrow the material on each shoulder and then work it gradually into the surface under traffic. Ordinarily it is very successful, but we find two little objections to this method, namely; that in case of rain the ridges of sand hold water on the road, and in case of a snow blockade they are gen-

erally pushed into the ditch by the snowplows.

Sand-Clay Construction

Although we have built a few miles of sand-clay on clay according to the usual rules for construction; that is by a heavy application of sand together with scarifying, discing and mixing, nearly all the treatment of our clay roads has been by the light surfacing process. We have preferred to put on less and put it on oftener for the reason of less initial cost and less inconvenience to traffic while the surface is being formed.

Roads in the sandhills or on such sandy loam as to contain no binder worth mentioning are more difficult to give a satisfactory surface. We have used two methods:

1. Put on clay 6-8 in. thick to furnish the binder and then spread the coarse sand on it in the usual manner, or

2. Put on 6-8 in. of a natural sand-clay mixture from some pit.

Naturally which method is used depends entirely on what materials are available. The blowsand at the side of the new road bed is worthless except to shoulder up with on a very flat slope.

This work is generally done in the fall and winter under favorable conditions of soil and labor supply. We have been fortunate in that it has been rarely necessary to haul material more than 6 miles. Favored by such conditions, the cost of placing or renewing a sand surface on a clay road usually does not exceed $600 per miles and the original sand and clay roadbed for a sandhill road not over $1,500-$2,000.

In the selection of material we note one point. We do not like to use a fine grained sand or one testing less than 10 per cent on the ¼-in. screen. Such material does not work into the surface satisfactorily and tends to produce waves of chatter bumps under traffic. Screening of sand to proper grading can easily be done, if you are getting it from a pump; by putting a flat screen in the bottom of the discharge trough.

Reno County has 62 miles of pavement on its 370 miles of county and state road. We expect to build more pavement but at the same time we intend to continue sand surfacing on the rest.

Considering the fact that practically every county in the state has available some kind of local materials—it may be sand, gravel, chats or limestone screenings—I believe it is worth while to bear in mind the possibilities of improving existing earth surfaces with them on those roads that it is not possible or not necessary to otherwise improve in the near future.

CONTRACT LETTING AND CANNIBALISM

(Editor's Note: The following article from the "Central Constructor" has been rather widely quoted. We should say it has the merit of frankness and may do some good if it suggests to the contractor reader that he has blamed everybody but himself for his troubles and should now try that and see where it leads him. Get next to yourselves, boys!)

Deep in the jungle on some dinky island in the South Pacific a savage gets hungry for a tasty bit of "white pig," and he is psychologist enough to know how to set about getting what he wants. He squats under a tree and with a hardened palm begins to beat upon his tom-tom. His fellows, who are gathered about the thatched hut of the missionary down by the beach, hear the primitive call, drop their prayer books and scamper for the thicket, shedding their plug hats and bandanas as they run, unlimbering their lances and smearing red clay on their faces to be fully prepared for the war dance when they locate the hungry musician. And as the group grows the tom-tom speeds up, the dancers swirl through the trees in a swiftly moving circle until the sun plunks under the western waves and darkness settles over the island.

Then they all go back to the beach and eat the missionary; and between missionaries they feast upon the unwary among their own or some neighboring tribe.

Probably none of the south sea writers of recent years ever witnessed a construction letting in the middle west. They might not recognize the savage and primitive flavor that prevails at these gatherings, even if they did sit in as guests. But the tom-tom gets its regular thumping, the war paint and long stickers are in evidence to the initiated, and the wild fervor that prompts the born cannibal to return to the beach with a big iron kettle and an armful of firewood—the same excitement that blots out all restraint of civilized judgments—takes a hold upon the hungry man at a

letting, and the appetite that results demands and receives satisfaction.

From the land of schoolhouses and picture theaters and radio concerts we look with condescension on the untutored aborigine who forgets what we have tried to teach him; we smile a bit at his childishness, and send more missionaries to try again.

But we seem to forget our home missions. We have wiped out the motto about charity beginning at home, and we go on letting the contractors cut each other to bits, boil those who join the powwow (and a lot of those who don't) and keep up a system of cannabalism that compares favorably with that encuntered by that doughty old sailor Captain Cook several hundred years ago in Hawaii.

The cost-accounting missionary lands on the beach with all the enthusiasm of the congregation of bond companies, officials, and other good folks who send him out to convert the benighted. The natives gladly accept the prayer books with figures on overhead, interest, profit, and contingencies. They study them industriously in their huts.

Then, during services, over the horizon floats the scent of a stewing contract. The gaunt fellow who hasn't tasted profits for almost a season feels a stirring within him. He listens with apathy as the missionary says, "Now turn to page 23 and we'll sing the grand old number, 'Depreciation.'" The music sounds dimly in his ears as he slips out of the back pew and starts for the campfire. He drops the book as he leaves. One by one his fellow natives experience the same urge and one by one they follow him.

They are a good-natured crew as they meet. But under the surface of the jovial banter about some dainty tidbit featured at the last letting there runs a strong current of excitement, closely akin to the bloodlust of the islanders. And finally the grisly scramble about the kettle, when the struggle for the spoils touches its climax, has in it an element not altogether unlike cannibalism.

An experienced contractor recently put the question, "What do you consider the outstanding evil of the contracting profession?" And the answer was unanimous among those present, "The contractor and his wild bidding practices and unbusinesslike methods of arriving at a figure."

Prominent among those who are responsible for this condition is the gambling contractor—the one who thinks that he can build for a certain figure because the other fellow has named some such amount, and who arrives at his bid without a semblance of consideration of costs. With this gambler goes the one who bets that he can get by under a contract which is almost certain destruction on its face. A recent private letting brought out bids from six local and two outside contractors. Practically every one of the local contractors had previously been severely burned in trying to execute a contract exactly like that submitted for their signature at this letting. Yet they rushed at the job and any one of the eight would have signed up for all of the agonies which the contract unquestionably involves for the man who gets it.

Equally prominent among the contributors to the present state of affairs is the ego-maniac who thinks he can corner the construction market for the year. He has seen the same thing tried time after time by his predecessors but can't quite face the facts of the other fellow's disastrous experience in the same attempt.

With these two goes the fellow who adheres to the creed that the contractor must contract, be it ever so painful. He has to keep his organization together; he has to keep his hand in, or the other fellow will forget that he is in the game and will leave him out of consideration if ever a contract does come along in which there is a chance for an actual profit.

In the past we have had considerable to say about the occasionally unfriendly or unreasonable engineer or architect. We have criticised statutes, plans and specifications which impose what we have regarded and still regard as inequitable burdens upon the contractor. We have spoken frankly against the bond evil. We have even deplored the inclemencies of the weather which has seemed at times to conspire against construction.

But in the last analysis we are inclined to agree with the verdict that the outstanding evil in the construction industry is the contractor who bids without recognition of ordinary common sense, who drops his books and prances when the tom-tom sounds.

RECENT RESULTS OF HIGHWAY RESEARCH IN ILLINOIS

By V. L. Glover, Engineer of Materials, Illinois Highway Department, Springfield, Ill.

(Editor's Note: The following is from a symposium on Highway Research as Developed by the State Highway Departments published in the July issue of American Highways, organ of the American Association of State Highway Officials.)

Since the completion of the tests at the Bates Experimental Road, investigational work carried on by the Illinois Division of Highways has been extended to include the many problems which have appeared as the construction work progressed and the roads were subjected to heavy traffic. Many varying and different subjects have been studied, but, in the main, the work has classified itself roughly into four groups:

1. Pavement Design.
2. Concrete and Concrete Materials.
3. Methods of Tests.
4. Miscellaneous.

Group 1. Pavement Design

Under this group many subjects have suggested themselves and the principal ones will be discussed briefly.

a. *Efficiency of Various Types of Construction Joints*—This is a continuation of one phase of the Bates Experimental Road determinations of the percentage of the load transferred across different types of transverse joints. The Illinois pavement design calls for a three-fourth-inch round bar in each edge of the pavement parallel to the center line. The purpose of the investigation is to determine the efficiency of this bar in transmitting the load across transverse cracks and joints under different temperature and seasonal conditions. In addition to the round bar, the use of a 1½-in. Tee bar is being investigated for a comparison of the resistance to cross bending and bearing area. This investigation is under way at the present time. It will be necessary to determine the ability of the bars to transfer the load across the joint under as many different seasonal conditions as possible. It is evident that the condition of the subgrade and the seasonal variations will have a considerable influence on the efficiency of the joint, but just what the effect is has not been determined.

b. *Change of Pavement Surface During and After Curing Periods*—It has not been known definitely whether the surface of a concrete pavement remained the same during and after the curing period, or whether variations occurred over a period of time. This was studied over a period of three months on about 4,000 feet of pavement by means of a 32-wheel profilometer. The conclusion was reached that there is no appreciable change in elevation either during or after the curing process.

c. *Evaluation of Stress Set Up by Impact Loads* — By this investigation an attempt is being made to evaluate the effect of impact loads by determining the static loads required to produce corresponding deflection curves in pavement slabs. Because of the cushioning of the rubber tire, it was found possible to express the dynamic forces in terms of static loads which produce equivalent elastic curvatures of the pavement, and, consequently, equivalent stresses in the concrete and the same deflections of the slab. Empirical formulae have been developed which conform reasonably to the data collected, and the manner in which the different factors, which are the sprung and unsprung parts of the truck, the spring and tire conditions, possibly the radius of the wheel, the speed of the truck, and the unevenness of the pavement surfaces, influence the impact effect is brought out definitely.

d. *Stresses Set Up by Multiple Loads* —Some work has been done in attempting to evaluate the stresses set up in the pavement by multiple loads, such as the six-wheel truck. Some deflections and measurements of stress have been made but no definite conclusions have been made.

Group 2. Concrete and Concrete Materials

Under this group the following investigations have been made:

a. *Effect of Gradation of Coarse Aggregate on the Strength of Concrete*—In some sections of Illinois, coarse aggregate having the maximum size required in the specifications is hard to obtain. This investigation was made for the purpose of determining whether a reduction of the maximum size affects the strength of the concrete. Fifteen graduations of gravel and 12 of crushed stone were used. Transverse tests on 440 specimens, and compressive tests on 264 cylinders were made. Tests were made at the ages of 30, 60 and 90 days. Apparently, the principal criterion of strength as far as coarse aggregate is concerned is reg-

ular and uniform gradation from the largest size to the smallest. The maximum size does not appear to regulate the strength.

b. *Effect of Stone Dust on Strength of Concrete* — Stone crushed and shipped during rainy weather sometimes has a film of dust and fine material adhering to it. To determine the effect of various quantities of dust present in the coarse aggregate on the strength of the resultant concrete, an investigation was made which included 180 transverse and 162 compressive tests. The percentages of dust by weight of coarse aggregate were 0, 1, 2, 3, 4, 5, 6, 7 and 8 per cent. In general, a decrease of both compressive and transverse strength was observed for increasing percentages of dust, the effect being more pronounced on the compressive strength.

c. *Bulking of Sands* — It has been found necessary to consider the bulking effect of varying amounts of moisture in the sand used in concrete, since in this state field mixes are controlled entirely by the volume method. The laboratory method consisted of studying the bulking effect of sands with varying moisture contents, different gradations, and various methods of manipulation. This investigation developed the following facts:

1. Fine sands bulk more than coarse sands.

2. When the bulking is not corrected, the deficiency of sand in the mix will amount to from 20 per cent to 25 per cent, thereby causing a shortage of mortar which will reduce the workability of the concrete and cause difficulty in finishing.

3. Lack of sand in the mix due to bulking will require an excess of cement per unit volume of concrete.

4. The varying moisture content in the sand leads to an uneconomical and nonuniform concrete.

d. *Accuracy of Field Proportioning*— This investigation was undertaken for the purpose of determining some method of measuring accurately the loose and compacted volumes of the fine and coarse aggregates at the proportioning plant, the variation in volume, the percent of voids, the gradation, the percent of compaction of successive batches of coarse aggregate, the degree of compaction caused by haul and by inundation of different sands with varying moisture content, as well as their uniformity of volume in the loose and compacted state. During the course of the investigation 40 construction jobs were visited and the material tested. At each job the entire batch of coarse aggregate was tested for initial volume, final volume, percent of settlement, percent of voids, percent of moisture and gradation of the material. The entire batch of sand was tested for loose volume, final volume by haul and by inundation and the percent of moisture. A sample was also taken for sieve analysis.

From this investigation it was found that the average variation of actual field volumes of coarse aggregate at 40 proportioning plants was within 2 per cent of the theoretical volume; that the average variation of actual field volumes of fine aggregate showed a deficiency in the sand of 8 per cent, based on the inundation volume and not on the resulting volume due to haul; that the use of compacted volumes of materials to conform to 1:2:3½ volumetric proportions gives an increase in transverse strength over the strength obtained under present field methods; and that the workability of concrete in which angular material is used is more affected by a deficiency of sand than that in which the rounded material is used.

e. *The Study of Various Brands of Cement Available for Highway Construction in Illinois*—This investigation consisted of a study of the strength of different brands of cement used in pavement construction. The gradation of the fine and coarse aggregate, the flow and slump of the concrete, and the curing conditions were maintained at a constant, the only variable being the cement. A 1:2:3½ volumetric mix was used. The concrete, made from 16 brands of cement, showed a rather wide range in both transverse and compressive tests. Complete chemical analyses, as well as the usual physical tests, were made. The internal temperatures generated during setting were taken by means of thermocouples embedded in cubes of neat cement, and considerable difference was found in the time at which the specimens reached the maximum temperature. This investigation is still under way.

f. *Effect of Temperature at Setting on Strength*—The purpose of this investigation was to ascertain the length of time necessary to protect fresh concrete in freezing weather using various methods. One hundred beams were made and subjected to different temperature conditions before being placed in freezing temperature. The periods during which

they were kept above the freezing point before being placed outside varied from 0 to 96 hours. Comparisons of plain concrete beams and those in which calcium chloride was incorporated were studied, as well as the protecting influence of straw. While this test is still to be continued and the results checked, the indications are that the incorporation of calcium chloride is the greatest assurance against poor concrete at temperatures near freezing. Protection of the surface by straw materially aids in attaining strength and protection from freezing for 15 to 20 hours greatly increases the strength, although the surface may peel if subjected to freezing at this early period. Concrete that is frozen apparently gains less than one-fourth of the ultimate strength of the same kind of concrete which is not frozen.

g. *Surface Curing of Concrete*—This investigation was undertaken to determine the possibility of securing a suitable curing medium which would permit the opening of concrete pavements to traffic at an earlier period than 21 days. Over 500 concrete beams were subjected to this method of curing and then tested for transverse strength. Most of the specimens were broken at the ages of 14 and 28 days. It was found that the important period during which the slab should be kept from drying out is the first three days after placing; that the coating of the surface with some sort of skin application has no curing effect, since the application acted as a conductor of heat and the evaporation took place the same as if the surface was unprotected; that specimens placed on an oiled subgrade showed no increase in strength above those placed on moist subgrades. Calcium chloride treatment and the application of wet soil for a period of 14 days showed comparable strengths.

h. *Bond Between Concrete and Coated Bars*—The purpose of this investigation was to test the bond between the edge bars and the concrete when various types of coatings were applied to reduce bond. From the theory of the Illinois design it is desirable to prevent bond between the longitudinal edge bar and concrete. Twelve different materials were used for bar coatings, including paints, asphalts, grease, commercial compounds and oils. The results of this investigation led to our present specification of a thin film of heavy oil for a coating. A thickness of coating material greater than the mean deformation of the concrete defeats the purpose of the bar, for the concrete will fail before the bar becomes effective.

Group 3. Methods of Tests

a. *Freezing and Thawing Tests*—The resistance of the coarse aggregate to destruction by the elements, and the cleanliness of both fine and coarse aggregate are of great importance. To secure definite information on the durability of the coarse aggregates, we are conducting freezing and thawing tests on samples of representative crushed stone used in highway construction in Illinois. For these tests a freezing box of the design recommended by the American Society for Testing Materials in their standard specifications for drain tile has been used. Temperatures of from 0° to +5° Fahrenheit are easily produced with an ice and calcium chloride mixture. The capacity of the apparatus, however, is so small that at present the data are incomplete, since only a few samples have been tested completely. The tests are also applied to concrete specimens made from aggregate previously tested with the hope that valuable information will be secured from correlating these results with the results of the present standard tests of the aggregates alone.

b. *Sodium Sulphate Soundness Test*—As a possible substitution for the tedium of testing the durability of aggregates by actual freezing and thawing, we have also been using the sodium sulphate soundness test. This method, however, is open to a serious objection, in that there is no definite quantitative measurement of the final result. Further, the size of the sample tested is so small that it may not be truly representative. To relieve these two difficulties in the testing of gravel the use of duplicate samples, prepared as for the standard abrasion test for gravel, have been studied. One sample is subjected to the sodium sulphate soundness test, and then soaked in water to remove as much of the salt as possible. After being dried both samples are subjected to 5,000 revolutions in the Deval machine with the usual abrasive charge of six steel spheres, but using a slotted barrel instead of a plain barrel. It is hoped that the use of some such combined soundness and abrasion tests may give a satisfactory means of gauging the durability of the material, as well as the percentage of soft and inferior particles.

c. *Transverse Strength of Concrete*—In the Illinois pavement design the transverse strength rather than the compressive strength is the important factor. This fact, together with the non-uniformity of ultimate compressive stresses of concrete has caused some question as to the value of the compressive test. An investigation was carried on in which a comparison was made of 500 transverse tests on beams from which a like number of cores were drilled for the compressive tests. For the transverse test the cantilever method was used by which the concrete is subjected to the same type of stresses which it undergoes in the slab. The variation from the results in the cantilever tests is only about one-third of that found in the compressive tests. The cantilever test opens a field which has hitherto been impossible, since by the means of this test the effect of admixtures, questionable aggregate, cements, weather conditions, and uncertain elements may be determined in the field, and, to some extent, the making of assumptions as to the probable strength of the concrete eliminated.

d. *Various Methods of Checking Pavement Smoothness*—This investigation was undertaken to determine the comparative accuracy, efficiency, and adaptability of various types of profilometers and straight edges when used under similar conditions in the field. The results are incomplete at this time.

e. *Subgrade Tests*—It has been demonstrated that soils have widely varying physical properties, depending upon their physical characteristics and the amount of moisture present. Subgrade tests have been developed which bring out these physical properties, and these tests are being used in this State in preference to similar tests used elsewhere, for the reason that they are made under conditions more nearly approximating those found in the field, and are seemingly more accurate.

Group 4. Miscellaneous Investigations

a. *Soils*—Under this subject an attempt is being made to work out a soil classification system which will fit the conditions encountered in this State; also an attempt is being made to determine a method to control the volume change of soils resulting from a change in moisture content so that a stable subgrade may be assured. A subgrade expansion test was devised to determine to what extent the subgrade entered into the variation of the thickness of the pavement slab. So far this test has consisted of laboratory experiments only, but it may be extended to include field tests. At the present time a study is being made of the practice of jetting fills as a means of hastening their settlement. Considerable information is being collected at the present time on this subject.

b. *Oiled Earth Roads*—A comprehensive study of oiled earth and road oils has just been completed. The object of this investigation, which continued over a period of two years, was to determine the suitability of various types of commercial petroleum road oils for the surface oiling of earth roads, to study the methods of oiling and maintaining these roads, as well as the effects of traffic, soil, and weather conditions. This investigation was brought about by the fact that a large quantity of road oil is used each year by the counties and townships in the maintenance of earth roads.

c. *Crack and Joint Fillers*—An investigation has been under way to determine the best methods of maintaining cracks in concrete pavements. Several types of filled material were used, and the action of these materials under weather and traffic conditions was closely observed. One set of fillers had penetrations ranging from 24 to 200, and another set penetrations ranging from 98 to 250. From the observations it appeared that if the best results are to be obtained, the filler must be applied during low temperature periods while the slab is contracted, and that it must have a penetration high enough to permit adherence to the slab in cold weather. A filler having a lower melting point than the maximum temperature of the slab will drift in hot weather, and fillers having penetrations of more than 200 may track to a great extent during hot weather. Further, fillers applied in hot weather show signs of failure by splitting directly over the cracks when the slab contracts.

EXPERIMENTAL SAND-CLAY ROAD IN MICHIGAN

By A. R. Bailey, Engineer-Manager Washtenaw County, Mich., Road Commission.

(Paper read at annual conference on Highway Engineering at University of Michigan, Ann Arbor, Feb. 15, 1926.)

A little over a year ago Professor Blanchard conceived the idea of using one of the Detroit Edison Fellowships in

investigating sand-clay road construction as applied to this latitude. We all know that sand-clay roads are a success in the southern states where there is no frost action, however, we do not know whether they can be made a success in Michigan. Professor Blanchard arranged for a Detroit Edison fellow, Mr. C. S. Jarvis, to make a study of this subject with the idea of our carrying out the field work of construction during the year 1925.

In deciding where we would do the experimental work with sand-clay we took into consideration the source of the road to be constructed and for these reasons a section of the North Territorial road was chosen. This section connects M-65 and the Pontiac Road and is about five miles in length. Before any construction work was started, Mr. Jarvis went over the road using an auger and took test borings, numbered the samples and then took them to the laboratory where the tests were completed and recommendations were afterward made as to the amount of sand necessary to be added to the natural soil to give the desired results.

A grading contract was let during April and May 5th the contractor started grading work at the M-65 end of the road and worked east. As soon as the first mile and a half of grade was ready for sand which was early in June, we channeled the grade as is customary in building a gravel road except the depth was much less. The sand was then spread from the trucks the same as gravel is handled and immediately the clay that had been thrown out from the channel was thrown back over the sand and a team with a spring tooth drag was used for mixing the sand and clay. There was very little traffic over the road on account of the easterly portion of the road being under construction during the summer so there was not much traffic for compacting the materials. This mile and a half has been under traffic since the middle of June except for one month during the time a bridge was being constructed in the middle of the section. We found the sand compacted with the clay quite readily even under the light traffic and the road had all the appearances of an ordinary gravel road. In the fall there was an unusual amount of rainfall; however, it had no effect on this section of sand-clay except to cause ruts to form during each rain. As soon as the rain had stopped and a grader or spring scraper floated the surface, the road was again smooth and contined this way until the next rain.

Grading work progressed very slowly on the remainder of the road so that no further surfacing was done with sand until early in September. The sections, approximately a mile in length, were surfaced as rapidly as completed, the same method being used as described above on the first section of a mile and a half. We did not learn until late in November that owing to the extremely wet season we had made a serious mistake in channeling the subgrade before applying the sand; this does not apply to the work done in June. As you may suppose this channel held the water and inasmuch as the entire grade was fresh and soft from the rains, the road rutted and during the extremely wet weather in November sections of it became practically impassable. If we had placed the sand directly on the subgrade we are certain the conditions would have been better providing proper crown had been given to the road to throw the water to the side ditches. We graded the road to a flat section, the slopes being one to three on the roadside section of the ditch and one and a half to one on the back slope. Our idea was to put the necessary crown in the finished section by using some of the subgrade material plus the sand. A sand-clay road should have a little more crown than the ordinary gravel road and unless this is done, the water is bound to soak into the surface rather than run off.

During the month of December after the ground was frozen sufficiently to carry heavy trucks with loads, we completed the surfacing of a half mile that had been channeled before the cold weather came. After this was completed we surfaced the remainder of the road with sand without channeling. It was possible to use a grader and smooth the sand especially on days when there was sufficient sun to soften the surface. This would not have been possible with gravel but with the sand the grader was able to cut a half inch or more at a time and the result has been that the entire section of road has been in a good passable condition throughout the winter.

Next spring we propose to put a heavy grader and tractor over the road as soon as the frost has gone and the ground is in a settled condition, and shape the surface after which we plan regular maintenance work the same as is used on any gravel road. We have already learned

that in some places much more sand is required than in others. There were a very few places where the subgrade contained a larger percentage of fine material so that less sand was needed, however, the entire road might be considered as a heavy clay road and an amount of sand varying from 2 to 6 in. in depth was spread over a width of 16 ft. We also plan to maintain this road with sand at least for one or two years during which time the traffic probably will not exceed an average of 300 vehicles per day. After the second year a fourth section of this road will be opened to the west side of the county which will allow traffic from the northwest part of the county to travel easterly to the county line and into Plymouth and Detroit without passing through Ann Arbor and Ypsilanti. When the traffic has increased to five or six hundred vehicles per day, we plan to use gravel for maintenance.

In estimating the cost of building this road as sand-clay instead of gravel we took into consideration the cost of loading and hauling the sand and also allowed a cost of 10c for the material which should be considered the same as would the gravel. The sand used is washed from the gravel at the county washing plant. and the allowance of 10c per yard is to cover the payment we make for the material removed from the pit regardless of whether it is sand, gravel or stone. The loading was all done with a steam shovel and cost approximately 10c per cubic yard. We of course, have to meet the argument that it would cost no more to haul gravel than it would to haul the sand which is true, however, we can build a sand-clay surface for a light traffic for much less than it would cost to build a gravel road because a much smaller quantity of sand is used per mile than could be used if gravel were the material. We used approximately 861 cu.yds. of sand on the first section and roughly 800 cu. yds. on the other section, and if we assume an average of 900 cu. ds. per mile it means a saving in immediate expenditure of about $2,000 per mile.

Naturally we shall all be very much interested in watching the condition of this road when the frost leaves the ground next spring and having constructed a section of it during the dry weather so that it was compacted before fall rains came, and the other sections during the late fall, it should give us an opportunity to observe the effect of the spring weather on the two types of construction. We hope the experiment will be a success as it would allow us to use the waste sand from our washing plant, where it could be economically hauled, and it should allow us to build a secondary type of road where it is known the traffic will be light, at a much less cost than the regular two course gravel road. We hope to learn a great deal from this experiment and should be able to give you a more interesting report next year at this time.

Bituminous Treatment of Gravel Roads

We started treating the Whitmore Lake Road known as . L. 65 running north from Ann Arbor, during the year 1923. Although such work had been done in Kalamazoo County previous to that time those of us doing the work in Washtenaw County had no experience in such work and we were asked by the State Highway Department and Professor Blanchard to do this work more or less as an experiment. During that year three different sections were treated and the work was followed very carefully throughout the season and during the following year 1924, these same sections were retreated, and the remainder of the road was treated for the first time. A short report was given at this conference last year which also included the cost of the work during 1924 and some of the things that we had learned.

We found that retreatment work was very expensive on a road where there is traffic amounting to 1,000 vehicles or more per day for the reason that chains used on the cars during the winter months and the heavy traffic during the time the frost is leaving the ground cause a large number of pits to form as well as wear off the surface treatment. pits with stone and bituminous material before the regular treatment can be made and because of the fact that such patching is entirely a hand labor job the cost is extremely high.

After watching the work during 1924 and studying the surface conditions of the road during the spring of 1925, we decided to scarify the entire road, approximately nine miles, before doing any treatment work.

When this road was constructed there apparently was no limit to the size of stone used in the metal so that the scarifying operation brought up large numbers of over-size stone which had to be removed. This process was carried out over the entire season. Work started as soon as the frost left the ground and hence the spring rains aided in compacting the gravel preceding the treatment.

The method of treatment used was the one that has been followed in other counties in this State as well as in other states. The surface of the road was first swept clean of loose material and dust after which approximately one-quarter gallon of oil per square yard was applied. About a day later the second application of a similar amount was made and immediately followed by the cover material. Some slag was used and the remainder of the material was pea gravel from the county washing plant. During the treatment work traffic was detoured over a parallel road and some grader maintenance work was done on this detour. Watchmen were provided at the ends of the section to which the second application was being applied. This naturally increased to a certain extent the cost of doing the work and with the limited budget set up for the year 1926 we expect to get along without detouring traffic and without watchmen.

During April last year the speaker accompanied Mr. Richards of Lenawee County to Dane County, Wisconsin, where we observed the conditions existing on roads that had been surface treated the previous year and also saw treatment work in actual progress. Many of you may not know that Dane County, in which the city of Madison is located, treated 125 miles of gravel road last year at a cost of approximately $135,000, all of which money was raised by taxation. It is a rich county and the people appreciate the dustless condition of the roads so treated. We had heard about the so called "Wisconsin Method" of surface treated gravel roads but there were some questions about it which were not clear in our minds. After observing the work for a couple of days we were convinced that the method had considerable merit in it and it is planned to use this method in Washtenaw County during the coming season. We do not know if the State Highway Department will want us to use this method on T. L. 65 but if not we shall use it on county road treatment work. You have undoubtedly heard or read of the Wisconsin method which might be termed the "Turn Over Method." The road surface is not swept as has been done in Michigan during the last few years but an application of oil is placed directly on the road surface which should have a light surfacing of loose material upon it, in other words the normal condition of any good gravel road. Immediately after this treatment a tractor and heavy grader is put on the road and the loose material on one-half of the road surface is pushed to the opposite half of the road. The second application of oil is then placed on the clean, smooth surface. The grader then pushes all of the loose material from the opposite side of the road over upon the treatment just made. The distributor follows with an application on the second half of the road. This completes two applications on the entire road surface, after which ordinary gravel road maintenance equipment is used, either Fordson tractor graders or spring scrapers, and the surface is worked so as to keep the road smooth at all times. The traffic will compact the loose material which has been treated with the bituminous material so that in a very short time, depending entirely on the amount of traffic, the treated gravel becomes packed so that no loose material remains on the surface. The road is then ready for its final application of oil which must of necessity be light and the distributor is followed by trucks spreading the cover material. At this point it might be well to mention the fact that Dane County mechanics have developed a spreading device that can be attached to the rear end of the ordinary gravel truck and which will absolutely distribute gravel or sand in a uniform layer on the surface of the road. Pea gravel is used in Wisconsin as cover material.

As there are three applications of oil used in the Turn Over method it follows that the cost of oil will be somewhat increased, however, it is believed that this added cost is about offset by the saving in the cost of sweeping as usually practiced.

During our visit to Wisconsin we saw roads that had been treated during 1924 by the method above described also roads being treated by this process as well as the various stages of the work. We believe that it is the best way of doing this work at the present time and are fully convinced that good results can be obtained and at reasonable costs.

During the year 1925 we planned to use calcium chloride as a dust layer on two county roads extending from Ann Arbor to Dexter and Saline respectively. The traffic on these two roads was quite similar , however, not as gerat as on the M-65 treatment work described above. The construction of these roads just mentioned was different as to width of metal, being 9 ft. as compared with 16 ft. on the

COMPARISON OF 1925 MAINTENANCE COST OF THREE WASHTENAW COUNTY GRAVEL ROADS.

Cost Account	Road Name Dexter	Saline	Whitmore Lake
1. Dragging and Patching	$2,100.29	$2,530.10	$2,435.66
2. Grade	36.49	126.75	237.67
3. Resurfacing	3,886.71	4,828.21	.....
4. Drainage	9.47	76.04	0.95
5. Signs	81.39	43.39	63.24
6. Dust Layer	2,743.35	3,385.82	8,325.02
7. Snow Removal	91.48	94.12	133.53
8. Traffic Census	25.26	25.26	44.21
9. Additions and Betterments	.....	228.14	140.08
Total Cost for the Year	$8,974.44	$11,337.83	$11,380.36
10. Dragging and Patching, cost per mile	320.00	322.00	287.00
11. Resurfacing, cost per mile	418.00	430.00	981.00
12. Dust Layer, cost per mile	592.00	614.00	.....
13. Other Costs, per mile	38.00	76.00	74.00
Total Average Cost per mile	$1,368.00	$1,442.00	$1,342.00
14. Traffic Count	1,000	1,046	1,954
15. Total C. Y. Gravel used	1,450	2,000	550
16. Average C. Y. Gravel used per mile	221	254	65
17. Length of Road in Miles	6.56	7.86	8.48

M-65 route, however, one respect in which they did not differ was in the use of oversize sone. We, therefore, planned to scarify each road during the spring 1925, then resurface them, and later give them two applications of calcium chloride. Our program for the season was carried out exactly as described above. We maintained the two gravel roads in the ordinary fashion and maintained the bituminous treated gravel on M-65 by hand patching, where and when necessary, and from month to month watched the maintenance cost of the three roads.

The speaker believes you will all be interested in the cost figures that have been prepared covering these three road maintenance jobs and because of the fact that you can remember only a few figures from hearing them once, a table has been prepared so that you may see how it compares with similar work in your county. It is not the purpose of the speaker to depreciate or underrate the value of calcium chloride as a dust layer or binder, however, for gravel roads carrying about a 1,000 vehicles per day our experience of the last season seems to indicate that we might have maintained these two roads as cheaply with bituminous material as with chloride as far as costs are concerned. One of the gravel roads in question we knew would not have a sufficient amount of gravel for bituminous treatment as to depth and width and it was, therefore, our purpose to use the calcium chloride as a binder for holding on the road the resurfacing material rather than to allow it to be blown into the fields as dust. We are sure this accomplished our aim as there was plenty of material on the road surface when it went into winter weather. You also will be interested to know the average cubic yards per mile of gravel used on each of these roads as well as on the bituminous treated road. The material on the latter job was cover material only.

Comparison of Chloride and Bituminous Treatment Costs

If it is assumed that an average of 200 cu. yds. per mile of gravel must be added each year on a road carrying a traffic of 800 to 1,200 vehicles per day and if we assume a cost of $2.50 per cu. yd. for this gravel spread on the road then it would appear that between $400 and $500 per mile per year are necessary for resurfacing only. About 50 to 70 cu. yds. of cover material for bituminous treatment are used on each mile and the cost of this material should be deducted from the resurfacing cost in order to ascertain the amount of money that could be saved from resurfacing cost to be used toward the bituminous treatment work. On the the same basis of cost as resurfacing gravel, we find approximately $300 could be saved if no resurfacing work is done. Another very large item of cost on the ordinary gravel road is the grader work, called by our accountants, dragging and patching. The treated road does not need grader work but does require hand patching.

To carry our comparison a little further we shall assume that those two gravel roads are treated as was M-65 then resurfacing will not be necessary and the $300 thus saved will be available for treatment work. Cost of calcium chloride will also be saved or another $300 per mile. We can let the dragging and patching cost on the gravel roads offset the patching of the bituminous surface and in the cost of the above three roads you will

notice there is a fair allowance for patching. Does it not look as though we should be able to surface treat these roads as cheaply as they were maintained last year as ordinary gravel roads with two applications of chloride?

A bituminous treated gravel road is absolutely dustless and presents a smooth surface for travel throughout the entire year except for the pits that are to form during the winter months and which cannot be prevented unless an application of oil and cover material is made during the months of September or October. We believe that such treatment might prevent the formation of pits and also might obviate a treatment during the following spring. The State Highway Department Maintenance Engineer proposed a fall treatment to our county during the past season but unforunately due to the passage of the Ming Bill, the Commissioners could not see why they should spend the money for treating the road in 1925 in order to save the State that expense during 1926. They believed the State officials if placed in their position would have taken the same attitude.

There is one question that we have raised a number of times during the past year and which we are asking now that you may be thinking along this line during the months to come. If treatment work is continued on the same road over a period of years, will not the particles of gravel become thoroughly coated with bituminous material and will not there be so much bituminous material in the upper three or four inches of road surface that it will be impossible to hold the road in a smooth condition for traffic? Will not this surface form a thick mat and push so as to form rolls in the road surface? Perhaps when that time comes we shall find a way to overcome such difficulty should it then exist.

RESULTS OF HIGHWAY RESEARCH IN IOWA

By R. W. Crum, Engineer of Materials and Tests, Iowa State Highway Commission, Ames, Iowa.

(From "American Highways" for July, 1926.)

Results obtained from work completed on 15 research projects active during the year 1925, under the direction of the research organization of the Iowa State Highway Commission, and from work accomplished on three research projects in which this organization cooperated with other agencies. have provided valuable aids for the solution of problems arising in the design of highway bridges, culverts, and concrete pavement slabs; in the selection and testing of materials for use in concrete; in the economic use of road materials; in the preservative treatment of wood guard-rail posts; in the prevention of subgrade failures; in the selection and application of traffic line marking paint; and in the use of dust palliatives on gravel roads.

This research work is under the direction of the Engineer of Materials and Tests. A research assistant is directly responsible for a considerable portion of the work undertaken. The materials testing laboratories located near important centers of road materials production and at the headquarters of the commission are assigned various phases of a project or at times the whole project. On a few projects the work is continuous throughout the year, but on the majority of them the greater part of the work is accomplished during the winter and spring when routine testing work is comparatively light.

The cooperative projects were initiated by the Engineering Experiment Station at Iowa State College or by the Bureau of Public Roads. On these projects the Iowa Highway Commission furnished equipment, material, and technical assistance. In addition to these items, the Bureau of Public Roads project had some supervision furnished from the commission's organization.

The majority of the research projects active during the year of 1925 were concerned with some phase of the design or fabrication of plain concrete. The principal factors studied were, in general terms, the selection and testing of materials, the effect upon the strength of concrete of variations in the quality and character of materials, and the effect upon the strength of concrete of variation in the method of finishing the pavement slab. In the selection and testing of materials a constant effort is made for improvement in methods, to devise new methods to meet requirements of particular conditions, and to give aid in the establishment by the several national technical societies of standard specifications and methods of tests. In detail, the projects involving studies of the strength of the concrete as affected by various factors sought to learn the effect of the presence of shale or rotten stone in the coarse aggregate; the effect of the varia-

tion of the ratio of sand to coarse aggregate; the effect of the variation in grading of the coarse aggregate; and the effect of the application of the vibrolithic process of finishing the pavement slab.

It was found that the presence of shale even in very small amounts affected the strength of the concrete to some extent. The most serious effect, however, arises from the disfigurement of finished surfaces by the spawling of the concrete due to expansion of shale pebbles after the concrete has set. To prevent an unsightly surface, as well as to provide against impairment of the strength, the quantity of shale must be kept small. The presence of rotten stone in the aggregate affects the strength less than the shale, but this material disintegrates when exposed to the weather and crumbles under the action of traffic. More than about 3 per cent by weight in the coarse aggregate is likely to result in having the finished surface of the pavement present a rather speckled appearance, due to holes left by the rotten stone after about one or two years.

On all paving projects proportions of materials for concrete are specified on a weight basis, and in the proportioning they are actually weighed, thus insuring a constant relationship between the quantities of the various ingredients of the concrete mix. In order to effect the most economic use of materials available, a series of proportions designed to produce concrete of equivalent strength has been computed for use with the weight method of proportioning. A considerable number of specimens made in the laboratory or taken from the finished pavement furnished ample proof of the correctness of the theory of proportioning used.

Wide variations in the grading of coarse aggregate, due to differences in deposits and due to segregation by improper stock piling methods in handling materials, even from a single source, have caused much speculation as to strength of the concrete. An investigation of this factor has this far indicated that the variations in grading, except for improbable extremes, have a negligible effect upon the strength of concrete made with proportions having even a slight excess of mortar in the mix. This has permitted a mider range of use in different proportions of materials from certain plants which had been limited largely to use in only one proportion.

Methods of finishing pavement slabs have ever been with highway engineers a live topic. One of the more important projects active in 1925 was a continuation of a study of this factor. A comparison was made of the vibrolithic process of finishing and of the hand-tamping process. Concrete slabs 7 ft. wide and 11 ft. long and 8 in. deep were made and cured on a natural subgrade out of doors. These slabs are now being carefully taken up and sawed crosswise into beams 12 in. wide, 8 in. deep, and 7 ft. long. The beams thus obtained will be tested at the age of one year. Work on this project will be completed in 1926. This is the first work of the kind on an extensive scale, the preliminary work having been done in 1923, when about 800 beams were made and about 625 of them tested.

Another of the family of problems in concrete is the determination of a method of analysis which will reveal the original proportions of the mix. During 1925 an exhaustive study of the several methods proposed by various investigators was completed. None of the methods used alone has been satisfactory for a general case, although each method is quite accurate for the particular set of conditions used by the investigator. In studies of the uniformity of concrete of known proportions and in work with old concrete of an unknown mix, it is desirable to be able to determine the exact proportions of mix in the concrete of a given sample. The study made has led to the suggestion of a method making use of microscopic projections of polished surfaces. The method has not yet been given a thorough trial.

The behavior of reinforcing steel in pavement slabs has for some time been the subject of much conjecture. Opinions have been expressed that fracture of longitudinal roads would occur at the transverse cracks. From the work accomplished during the past year, it is quite evident that fracture of the rod is practically impossible in the case of smooth structural grade steel. Deformed bars of all grades and smooth bars of other grades will be studied.

During 1925 the investigations involving studies of subgrade soils and subgrade conditions were given constant attention. Subgrade failures on earth and gravel roads in the area of loessal deposits in northeastern Iowa were definitely accounted for and methods of treatment which are apparently effective were devised. These failures have each spring impaired the value of an otherwise adequate roadway, and have at times been a

real menace to the lives of motorists driving the road for the first time and unaware of the existence of these hazards.

The behavior of pavement slabs over various types of subgrade soils was the subject of another soil investigation under way during the past year. The nature of the study does not permit of very definite accomplishment in a short period of time. The work thus far has consisted mostly of the testing of soils, the development of tests, and the observation of phenomena prevalent for the various conditions.

An attempt to find aid for the solution of this problem was made in an investigation wherein about 3½ miles of road, 1¾ miles in each of two localities having a different type of soil, were treated with Portland cement and hydrated lime. At one location the road surface was a tough, heavy clay and at the other a light loess soil. At each location the road was divided into sections, and the individual section given a separate method of treatment, using 3, 5, 7. or 9 per cent of Portland cement or hydrated line. The admixture, either the cement or the lime, was incorporated in the earth of the roadway, which had been prepared by pulverizing to a depth of about 6 in.

The result of this treatment is not entirely a success for either type of soil. Some benefits, however, were observed, especially on the clay. Further observations will be required before a definite statement can be made as to the value of the treatment. It can be said that the results are such as to preclude any possibility of the use of such treatment on any earth road carrying an appreciable amount of traffic.

The Bureau of Public Roads initiated this project, which was carried on simultaneously in at least three States.

Three years ago a project was instituted to determine the comparative value of the various methods of preservative treatment for wood guard-rail posts. Installations of posts treated in various toxic liquids were made on primary roads at three widely separated locations in the State. These posts are inspected annually, and their condition carefully observed. At the 1925 inspection all posts were in good condition. The time is yet too short to obtain positive results.

Another phase of this project has been the determination of a type of white paint coating which can be used successfully over the creosote of full-treated posts. On the butt-treated posts, which are merely dipped in the treating liquid, the upper portion of the post may be painted with any good white paint, but on the full-treated posts the whole post is saturated with the treating liquid, which stains through the ordinary paint. From the results thus far obtained, it is believed painting over any full-treated post may be satisfactorily accomplished either by the use of aluminum paints or of a special priming paint beneath the white paints.

As the owners and operators of a considerable fleet of trucks, tractors, and road maintenance machinery, for all of which lubricating oils are purchased under specification by contract, it has become necessary to determine comparative lubricating value of oils used under various service conditions peculiar to the type of equipment owned.

Progress on this project has been slow and tedious. The method of precedure is as yet incomplete. The number of factors only partially controllable is large, and their relationships are too numerous for individual study. However, a start has been made, and a few promising clues have been discovered. Definite achievement of results should follow the continuation of the project as now outlined.

The study of impact stresses in highway bridges was completed during 1925, and a bulletin published by the Engineering Experiment Station at Iowa State College. The Iowa Highway Commission cooperated with the Experiment Station on this subject, which has been continuously active since 1923. It is a valuable piece of work and has produced results of especial value to the highway bridge designor.

Considerable progress was made on the culvert pipe projects initiated and carried on by the Engineering Experiment Station, with cooperation of the Iowa Highway Commission, especially during 1924 and 1925. Progress reports in the form of Experiment Station bulletins are being prepared for publication at an early date. The work has covered practically every loading condition to which a pipe culvert or sewer may be subjected and has investigated the design of reinforced concrete pipe especially in a most searching manner. A highly efficient new type and method of reinforcing has been developed and thoroughly tried out in actual size specimens of pipe with success.

Proposed work for the year 1926 is, for the most part, a continuation of the projects involving the study of subgrade

soils, the vibrolithic process, preservative treatment of wood post, the corroborative tests of strength of concrete, and lubricating oils. New work proposed consists of a cooperative study of a suggested improvement of the standard briquette tension test of cement and of a cooperative study of the value of the tension test of cement in predicting strength of finished concrete.

RECENT DEVELOPMENTS IN ASPHALT PAVEMENT RESEARCH

By Prevost Hubbard, Chemical Engineer, The Asphalt Association, New York, N. Y.

During the introduction and rapid adoption of asphalt pavements throughout the United States many years ago considerable study was given to the composition of asphalt paving mixtures with relation to their behavior under existing traffic conditions. Certain theories were evolved which could be sufficiently correlated with service results to produce satisfactory specification limits for the paving mixture itself and also of the individual constituents of the mixture. As a result of this study asphalt pavements soon came to be regarded as representative of the highest degree of scientific design and control.

With the marked changes in volume, weight and character of traffic which have occurred during the past 15 years certain modifications in the original design of paving mixtures have been adopted so that, in general, new construction has kept pace with the later traffic developments. In the minds of many careful thinking engineers, however, there has been developing a doubt of the logic, if any, back of certain of our customary and time-honored specification requirements, and for the past two or three years a number of investigators have been actively at work in an endeavor to broaden our knowledge of the laws which govern the behavior of asphalt paving mixtures under modern traffic.

Such general interest in the subject has developed that in January of the present year an Association of Asphalt Paving Technologists was formally organized for the specific purpose of investigating all phases of asphalt paving. This organization is expected to serve as a clearing house for all useful information developed upon the subject of asphalt paving. It has appointed a number of working committees, among the most important being one on research on paving compositions and one on control of street operations.

Given an adequate foundation, an asphalt paving mixture may fail when laid as a wearing course through improper design of the mixture itself or through faulty laying of the mixture. So far most of the research has been concentrated on composition of the mixture but the tremendous importance of certain construction details has been emphasized to such an extent by these studies that it is apparent that no real progress in the betterment of asphalt pavements can be made unless the two phases are developed simultaneously. Probably the most important problem today in connection with asphalt pavements is the prevention of shoving, rutting or other displacement under heavy motor traffic, through more logical control of composition coupled with closer attention to such details of construction as the obtaining of maximum practical compression, and original uniformity of contour.

Some five years ago the United States Bureau of Public Roads, in cooperation with a number of large eastern cities and The Asphalt Association, undertook an investigation of the cause and correction of shoving through a study of samples of existing pavements whose complete history could be ascertained. These samples of pavement were subjected to all of the customary methods of examination, but when the data was assembled it was found impossible to interpret results in the light of generally accepted theories governing such mixtures and it became apparent that a complete overhauling of the subject of design was needed.

In the first place it was quite reasonable to suppose that the older pavements which were at that time successfully carrying modern traffic had undergone certain changes since their original construction, so that their behavior would not necessarily be typical of the behavior of newly constructed pavements of the same original composition. The Bureau of Public Roads therefore undertook further to study the problem by means of short sections of asphalt pavements of varying composition constructed on a circular track at Arlington Farms, Va., and subjected to concentrated motor

truck traffic. At the same time the Bureau and a number of independent investigators turned their thoughts to devising some method of measuring by means of a laboratory test the stability or resistance to displacement of small samples of compressed asphalt paving mixtures.

Considerable progress has been made in the development of such a laboratory test and it is believed that the information being developed by these tests will shortly clear up the apparent contradictions encountered in the earlier investigations and will quite probably result in an entire revision of theories governing design. During the 1925 annual meeting of the American Society for Testing Materials a number of important papers upon this subject were presented and discussed. Further interesting developments were presented at the Fourth Annual Asphalt Paving Conference in Detroit during the latter part of 1925 and so much interest in the subject was displayed that an entire session of the Fifth Asphalt Paving Conference to be held in Washington, D. C., during the week of Nov. 8, 1926, will be devoted to asphalt pavement research.

Any investigation of asphalt paving mixtures is complicated by the large number of factors having a direct influence upon stability, such as size and grading of the mineral aggregate, percentage, type and quantity of mineral filler, quantity and consistency of asphalt cement, degree of compaction of the mineral aggregate, and maximum temperature of the mixture in service.

These factors are gradually being analyzed with reference to their importance and interrelationship. From the work already accomplished it seems safe to predict that in the near future a newer and more logical theory of design will be evolved which if put into practice will insure even more satisfactory service results than have been obtained in the past.

CLEANING OIL RESERVOIR OF GASOLINE ENGINE

By G. S. Hamilton, Climax Engineering Co., Clinton, Iowa.

Once every year it is desirable to drop the oil pan and thoroughly clean the reservoir of your gasoline engine. Simply changing the oil in the crankcase will not do. After a certain length of time, sediment will accumulate and only a thorough cleaning will remove it.

Many operators may be familiar with the details of cleaning the reservoir, but for the new user of industrial gasoline engines, the following instructions will be helpful. Proceed as follows:

1. Clean outside of pan to keep grit out of crankcase when open.
2. Drain off old oil.
3. Remove the oil pan stud screws and bolts.
4. Drop pan, being careful not to damage gasket.
5. Wash out pan with kerosene or gasoline and dry out with lintless cloth. Do not use waste. The threads and lint are likely to clog the oil ducts.
6. See that crankcase gasket is in good condition, and in proper position. If necessary, replace with a new one.
7. Cement gasket tightly to oil pan flange, using shellac.
8. Cover upper face of gasket with grease or hard soap soaked in water. This will check leakage and permit oil pan to be removed when necessary without breaking the gasket.
9. Replace pan and tighten screws and bolts, tightening a little at a time on each one to distribute the strain evenly.
10. Refill oil reservoir with proper amount of fresh oil of correct grade and see that indicator registers "Full."

INCREASING USE OF PLAYGROUNDS

A large increase in athletic games, tennis, golf, skating, swimming, organized hiking, and other outdoor recreations among teen-age young people is reported by the Playground and Recreation Association of America in its recently published Year Book for 1925.

This may encourage parents and others who are concerned over the physical, mental, and moral fibre of the youth of today and who deplore the frequent lack of opportunities for wholesome diversions to compete in interest with petting parties, lurid movies and similar amusements.

Practically fifty percent of the participants in public play activities today are adults, the Association reports. A recent study in a group of middle western cities shows that in Detroit the division is 46% adult and 54% children; in Milwaukee, 60% adult and 40% children. The Duluth program caters to adults in

winter, fall and spring to the degree of 75% and children in summer to 90%. It is only in cities that have recently organized public recreation that the great majority of participants are children.

Amateur athletic leagues reported in the Year Book survey totalled 6,181 in 1925 as against 5,292 in 1924. Conspicuous increases were reported in baseball, playground ball, basketball, quoits and volley ball. Organized hiking was reported in 297 cities, as against 200 the previous year. Facilities have increased to keep pace with the growing interest. Three hundred sixty-three new tennis courts were reported in 1925, bringing the total in 474 cities to 6,110. Three hundred eighty-nine new quoit courts, 159 athletic fields, and 97 skating places were among the new facilities added. Many new golf courses and swimming pools are reported throughout the country.

The increase in adult recreation, however, should not obscure the fact that the advances in the provision for children's recreation are notable. Six hundred fifty-four new play areas were opened in 1925 for the first time. There are now 1,121 outdoor playgrounds and 1,613 indoor recreation centers. Six hundred sixty-two cities reported an expenditure of $18,816,165.55 for public recreation last year. Playgrounds were donated in 83 cities.

CUTTING ACCIDENTS 45 PERCENT IN CEMENT INDUSTRY

What accident prevention experts believe is a record in the reduction of industrial accidents was announced recently by William M. Kinney, general manager of the Portland Cement Association, with the statment that since 1920 the "safety first" activities carried on by his organization have reduced the number of accidents in portland cement mills 45.2 per cent, the number of days lost due to accidents 40 percent, and the number of fatalities 33.3 percent.

"These records," explained Mr. Kinney, "apply to the whole industry, which employs more than 40,000 workers. Individual plants far exceeded these figures, however. Plant No. 8 of the Canada Cement Company at Port Colborne, Ontario, and the Duluth, Minnesota, plant of the Universal Portland Cement Company, each ran practically a year and a half without a single lost-time accident. Two men from each of these plants will be sent to the spring meeting of our association in New York City to receive the Portland Cement Association's safety trophy.

"When our members began this safety work 13 years ago they found to their surprise that the responsibility for accidents lay about 25 percent with the manufacturers, and about 75 percent with the men themselves. In many plants, our investigators learned, the machinery itself was dangerous. But the men themselves, either through ignorance or recklessness, were far more dangerous. They took chances constantly that were contrary to ordinary reason.

"We quickly induced our members to protect their machinery, and then we began an intensive campaign among the workers. The cement makers undertook all this work with the idea that they were simply spending money for their employees, but they quickly found that it paid them in actual dollars and cents, through improvement of their manufacturing personnel, reduction in delays and saving in accident compensation. Hence they have continued it enthusiastically."

AUTOMATIC PUMPING EQUIPMENT AT GRADE SEPARATIONS

Automatic pumping stations, for the collection and disposal of storm water, were recently installed jointly by the Detroit, Toledo and Ironton Railroad and Wayne County, Michigan, for operation at seven of ten highway grade crossing separations just completed on its northern division. These stations were designed to solve the problem of adequate storm water drainage in view of the low level resulting from depressing the highway.

Concrete pump houses were erected containing electrically driven pumps operating from local power lines. Concrete sumps sunk about 15 ft. below the pavement collect the water from catch basins located at intervals along the line of the depressed highways, the water being diverted underground through vitrified tile drains. Other catch basins above the pump house floors, but below railroad grade, provide receptacles for the water as it is pumped from the wells and are sufficiently elevated to allow a gravity flow through vitrified pipe into drainage ditches under the tracks.

American Well Works pumps are used at six of the crossings and all the pump

houses are equipped with General Electric motor drive with automatic control. A typical installation consists of two 8-in. centrifugal pumps within the pump house which empty the 17,800 gal. sump. Each pump has a capacity of approximately 860 gals. a minute and is driven by a 10-horsepower motor having a double squirrel-cage rotor.

Float switches in the wells control the pumping motors through magnetic switches. The pumps supplement each other, one or both being thrown into action as the level of the water rises. They are automatically thrown out of service as the water recedes in the sump. Maintenance costs are reported by the railroad to be comparatively small.

FLORIDA STREET LIGHTING

Among the progressive towns in Florida which are replacing their old systems of street lighting with new equipment are Mt. Dora, Sanford, Cocoa, and Vero Beach.

In the business district of Mt. Dora 80 General Electric Novalux units mounted on 15-ft. Union Metal Company standards have been installed. These are equipped with 1,000-candle power lamps and are spaced 100 ft. apart on the side, in staggered formation. On the main traffic arteries they are 200 ft. apart and are equipped with 600-candle power lamps. Alabaster rippled globes are used on both the main street and the travel arteries. Each fixture has an auto-transformer, to which current is supplied by means of a General Electric pole-type transformer.

Sanford is installing 370 ornamental Novalux units, with alabaster rippled globes and rippled canopies. These, equipped with 250-candle power lamps, will be mounted on King standards which are 11 ft. high. In the business districts the units will be 100 ft. apart, in opposite formation. In the residential section they are to be 200 ft. and staggered. This new lighting equipment is to replace small bracket units with reflectors using 60-candle power lamps.

Cocoa, a town of six or seven thousand is obtaining 197 General Electric Novalux lanterns. On the business street these units will be equipped with 250-candle power lamps, and will be mounted on Union Metal Company standards. They will be 100 ft. apart, in opposite formation. On the main travel thoroughfares the units will use 100- candle power lamps and will be 200 ft. apart.

Vero Beach is installing 227 Novalux units. These will be arranged 100 ft. apart in the business district, in opposite formation and will use 400-candle power lamps. On the main arteries of travel, the units will be staggered, 200 ft. apart, with 250-candle power lamps.

IMPROVEMENTS IN TRAFFIC LIGHTS

Two improvements in electric traffic lights have been announced by the Lynn, Mass., illumination laboratory of the General Electric Company. The first is a new type of wide-angle lens which incorporates a phantomless optical system, and the second is an electric synchronous control system for a number of traffic lights.

The new lens prevents the sun's rays from being reflected and thereby causing false or misleading signals during daylight hours. The wide angle lens also makes the signals visible from all points during daylight hours as well as at night.

The synchronous control apparatus is mounted in a small box which can be attached to a street lighting standard, or any pole along the curb. Two dials regulate the mechanism, causing the signals to change at any time periods desired. In each box is a self-starting synchronous motor which makes it possible to control the lights along any street for any distance without direct connection between signals, much the same as electric clocks are controlled from a central point. This means a great saving in installation costs.

NEW SYSTEM OF POLICE SIGNALS

Berkeley, Cal., has recently installed a new system of police signals. This system, at first used on a small scale, proved so successful that it is now used throughout the city. General Electric Novalux street lighting fixtures with four-way bowl refractors of ruby glass and equipped with 200-watt lamps have been placed at the intersections of the main streets. All of the lights are flashed by means of one controller at the city hall and remain lighted until the policemen on duty report to headquarters for instructions.

LINDELL BOULEVARD, ST. LOUIS —A REMARKABLE PAVING EXPERIENCE

Lindell Boulevard in St. Louis, is the most traveled arterial boulevard of that city, corresponding to Fifth Avenue, New York; Commonwealth Avenue, Boston; Broad Street, Philadelphia; Euclid Avenue, Cleveland; Michigan Avenue, Chicago; Wilshire Boulevard, Los Angeles; and Orange Grove Avenue, Pasadena, etc.

It leads to Forest Park where was located the celebrated International Exposition of 1904. Preparatory to the opening of that Exposition a rush construction contract was awarded on April 8, 1904, to the Granite Bituminous Paving Company, of St. Louis, for 59,209 sq. yds. of Warren pavement to be laid on compressed stone base, building up on the then old macadam road. The work was completed on June 7, 1904, and was then the record breaker of the world in road construction despatch.

During the Exposition the late Theodore Roosevelt was visiting the Hon. Rolla Wells, then Mayor of St. Louis, at his residence on Lindell Blvd, when President Roosevelt, looking up and down the boulevard, stated "This is the finest boulevard in the world."

Notwithstanding the subsequently desired construction improvements, this pavement, after 22 years' use by constant large volume of traffic, was in very good condition, and maintenance expense had been remarkably low. On a portion of the street, however, subterranean springs had developed; the crown was undesirably high and the abutting taxpayers (who had been assessed for the original pavement and are now being assessed for the reconstruction) feeling that no street in the world should be in better condition than Lindell Boulevard, petitioned the City to reconstruct the pavement in its entirety with WARRENITE-BITULITHIC, and on April 16, 1926, the contract was awarded to the Granite Bituminous Paving Company.

The accompanying illustrations show the detail of new construction, as well as general views of the 22 years old pavement before reconstruction was begun.

Ex-Mayor Rolla Wells, under whose administration the World's Fair project of 1904 was conceived and successfully completed says of the work:

"The re-surfacing of Lindell Boulevard, in the early Spring of 1904, from gravel laid on a Telford macadam foundation to

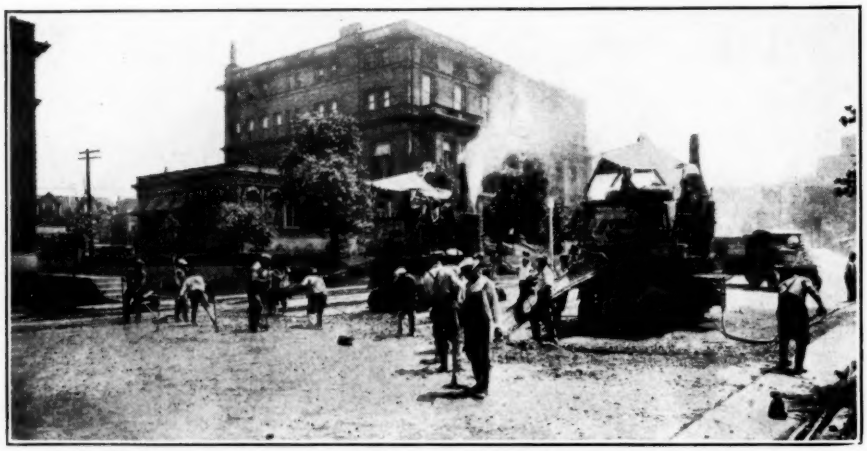
LINDELL BOULEVARD, ST. LOUIS, MO., LOOKING EAST FROM KINGSHIGHWAY
Bitulithic Pavement Completed June, 1904, Photograph Taken in May, 1926, Before Removal of the Old Bitulithic Wearing Surface.

RECONSTRUCTION OF LINDELL BOULEVARD, ST. LOUIS, MAY, 1926
Removing the Old Bitulithic Wearing Surface and Broken Stone Foundation to Reconstruct with Portland Cement Concrete Foundation and 2-in. Warrenite Bitulithic Wearing Surface.

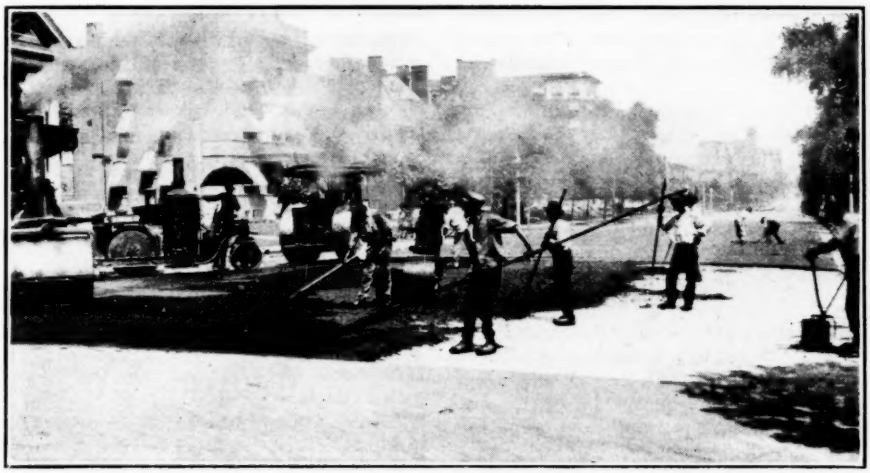
a Bitulithic pavement, was necessary owing to the opening of the Louisiana Purchase Exposition in the Western half of Forest Park."

"It was done in the face of very strenuous opposition on the part of many property owners along the Boulevard. After the work was completed, and the avenue thrown open, I had the satisfaction of being informed by some of the principal objectors, that the work was necessary and they were glad that it had been accomplished."

"From my observation during the last 22 years, I consider the Bitulithic surface as laid on Lindell Boulevard has been more durable than any that I have ever had any experience with."



RECONSTRUCTION OF LINDELL BOULEVARD, ST. LOUIS, MAY, 1926
Two 21-E Multi-Foote Concrete Mixers Working Side by Side Laying Portland Cement Concrete Foundation. Daily Capacity from 2,500 to 3,000 Sq. Yds.



RECONSTRUCTION OF LINDELL BOULEVARD, ST. LOUIS, MAY, 1926
Laying New 2-in. Warrenite-Bitulithic Wearing Surface on Portland Cement Concrete Foundation.

Mr. J. C. Travilla, Consulting Engineer, who was Engineer of the City of St. Louis during the 1904 construction, and subsequently for years Street Commissioner and member of the Board of Public Improvements of St. Louis, says of the City's experience with Lindell Boulevard:

"Lindell Boulevard from Grand Avenue to Kings Highway was laid out 100 ft. wide, roadway 60 ft. wide, side walk space on each side thereof 20 ft. wide. The Boulevard was originally improved with a Telford-Macadam foundation surfaced with washed gravel, a type of pavement adapted to light horse drawn traffic only, which served the purpose of developing the property at the time it was authorized.

"Over the protest of many abutting property owners, Hon. Rolla Wells, St.

SAMPLE OF WARREN PAVEMENT LAID IN 1904 ON LINDELL BOULEVARD, ST. LOUIS, MO., REMOVED IN 1926

This actual Size View of Sample Taken After Removal of Pavement for Reconstruction in 1926, Shows Original 2-in. Wearing Surface Still 2 ins. Thick, and Portion of Old Rolled Stone Base (Composed of Lighter Colored Stone), into which Wearing Surface had been Compressed with Resulting Adhesion of Base Stone to Lower Side of Wearing Surface.

Louis World's Fair Mayor, in 1903 recommended that a modern type of wearing surface be placed over the old macadam. After a thorough investigation of the merits of the recognized bituminous surface mixtures on the market, the Board of Public Improvements recommended a Warren Brothers Bitulithic Type of surfacing, laid upon a 2 in. binder course of compressed stone and tar, after scarifying and rolling the old macadam roadway in order to obtain a uniform contour.

"The resurfacing of the Boulevard was expedited to permit vehicular traffic to reach the Fair Grounds located in Forest Park which were to be opened to the public in June, 1904; the Boulevard being the only direct route from the central business and residential sections of the city. Weather conditions during the surfacing period were most unfavorable, part of the pavement being laid at a time of the year when rains and sleet interfered with the actual construction, but the work was pushed as it was deemed a public necessity to pave and open the Boulevard for traffic within the time fixed.

"The greater part of the total paving yardage was in good condition after a period of 22 years, except that the surface was 'corrugated' or 'wavy.' The causes for this condition of the pavement are readily understood by those familiar with local conditions, but it may be of interest to set forth the primary causes for these irregularities.

"1st. A very large number of public utility openings for house connections have been required in the foundation, and to thoroughly compact the replaced Telford and Macadam, without a slight settlement over the trench under continuous vehicular traffic, is almost impossible with the heavy clay soil in the St. Louis district.

"2nd. The original Telford-Macadam improvement was maintained by adding layers of crushed limestone and screenings, which resulted in an excess of fine stone grit being incorporated with the coarse macadam stone, bringing about capillary moisture in the foundation, which resulted in soft spongy spots under the pavement and caused surface irregularities to develop. (In the construction going on in 1926, it developed that seepage water from springs had infiltered under the foundation making it necessary to tile part of the roadway to obtain proper drainage.)

"3rd. The crown of the old Telford-Macadam roadway was excessive, due to constant maintenance with additional macadam and gravel. In order to provide a maximum depth of foundation at the time of resurfacing the roadway in 1904, the crown was not reduced materially because it was believed that it would give added strength in carrying wheel loads. While it may have accomplished that purpose to some degree, it had the damaging effect of concentrating vehicular traffic on the quarters of the roadway, thereby reducing the lanes of travel and bringing about an unequal distribution of the wheel loads over the roadway surface area and intensifying the "corrugated' surface.

"4th. Improved parallel streets to Lindell Boulevard had not been fully developed in 1904, resulting in an abnormal amount of vehicular traffic going over the pavement. Yet aside from the 'corrugations') the surface continued to remain in fairly good condition, raising the question among taxpayers as to whether or not a complete new surface was necessary at this time.

"It is a well known fact in street maintenance, that if a pavement, granite and vitrified brick block excepted, renders satisfactory service for a period of 15 years, the taxpayers have received full value for the money invested. The service value of the pavement laid in 1904 accounts for the willingness on the part of the interested property owners to petition the Board of Public Service to renew the surface with a type of pavement like that which had for 22 years demonstrated its merit."

NORTH CAROLINA ROAD-TEST TRUCK

By H. B. Shaw, Director, Engineering Experiment Station, North Carolina State College

In their road-test truck the North Carolina State Highway Commission and the Engineering Experiment Station of North Carolina State College have a valuable device for measuring the power required to drive motor vehicles on all sorts and conditions of road.

The unique feature of this test vehicle may be stated briefly as follows:

1. It has an electric drive superimposed upon the usual mechanical drive.

2. The motors are series wound, of the railway or battery vehicle type. The electric generator also is "series wound," which is unusual.

3. Instantaneous and average values of speed and of the electric current in the single main circuit are determined independently. From them, the power delivered to the vehicle mechanism is easily calculated.

4. The road test truck, at specific speeds, measures the average power instead of the tractive resistance. The latter, however, may be calculated from the power, speed, and mechanical efficiency.

5. The vehicle contains a specially constructed "antivibration" suspension for the graphic instruments, voiding the effects of the vehicle vibrations, tilts and jars.

6. An ampere-hour meter and the elapsed time are used to get the average value of the electric current for a run, instead of averaging the current from the charts of the recording ammeter. This saves much time.

The test vehicle is operated at a selected speed which, for accurate measurements, must be kept constant during a run. It requires some practice to keep the speed constant by manipulation of the throttle of the gasoline engine. The speed commonly used for test runs is 15 miles per hour, though tests have been made at speeds as low as 2 miles per hour and as high as 30 miles per hour.

A feature of this electric drive is that it does not retard the vehicle motion downhill nor will the vehicle measure the power when none is required, as when coasting. Consequently, the brakes have to be used to hold the speed constant on down grades of any consequence.

The vehicle will measure the power at different speeds on hilly roads, the power to pull through mud, sand, etc. To get the comparative horsepower on different road surfaces it is preferable to select fairly level roads and avoid the necessity of calculating and eliminating the effect of grades.

A large number of test runs on a race track showed, at 15 miles per hour, the following results:

10.30 horsepower when the surface was wet and muddy.

9.30 horsepower when the surface was partially dried.

8.50 horsepower when the surface was nearly dry and somewhat rough.

5.17 horsepower when the surface was in the best of condition, dry and fairly smooth.

The effect of the speed of the truck upon the horsepower required when the race track was in the best condition is shown by the following results:

At a speed of 2½ miles per hour, 0.67 horsepower.

At a speed of 5 miles per hour, 1.40 horsepower.

At a speed of 10 miles per hour, 3.10 horsepower.

At a speed of 15 miles per hour, 5.17 horsepower.

At a speed of 20 miles per hour, 8.10 horsepower.

At a speed of 25 miles per hour, 12.45 horsepower.

At a speed of 30 miles per hour, 19.00 horsepower.

Analysis of the internal losses, analysis of tractive resistance, recalibration and study of all the functioning of the test vehicle are now being made. The measurements are sufficiently delicate to permit very accurate adjustment of brakes, tests of the effect of different lubricants upon power losses, etc.

When the present laboratory investigations are completed, the test runs are to be resumed and continued for at least a year in order to get all-year, all-weather comparative horsepower for different road surfaces.

The further intention is to use the comparative horsepower as a basis for getting the difference in mileage cost for gasoline, tires and maintenance resulting from operation on different road surfaces. Neglecting other savings in cost due to hard-surfaced roads, the differences in cost per ton-mile for tires, gasoline and maintenance can be taken as the differences in cost per ton-mile for different road surfaces and used to determine the economy of highways.

The results are expected to demonstrate quantitatively the volume of traffic at which expenditures for first-class highways are economically justified, through saving more in the cost of vehicle operation than the additional annual cost of the improved highway.

SURFACE CRACKS IN GREEN CONCRETE

By T. J. Vitcenda, Materials Engineer, Wisconsin Highway Commission, Madison, Wis.

(The following article is from "Badger Highways" for July, 1926.)

A source of concern in all concrete pavement construction during the hot days of the summer season are the fine

hair-cracks which sometimes develop in newly laid sections of the pavement. These cracks are very fine, irregular and comparatively short. The true hair-crack seldom has a depth of more than a sixteenth of an inch. When they occur they are found in quite large numbers along a few sections of the pavement laid during the day. They generally begin to show about the time when the concrete obtains its final set, or about five to six hours after the concrete has been poured. From that time until the pavement is twenty-four hours old the hair-cracks, or checking, will develop very rapidly. Very infrequently does checking occur after a pavement is more than a day old.

The checking of a concrete pavement does not cause a serious decrease in the strength or life of the pavement. In fact, it would be hard to prove that any real harm results because of the cracks. However, an ugly sight is presented wherever considerable checking occurs. When the cracks are later tarred to prevent water from seeping into the concrete, a network of tar strips is left to greet the eye of the traveler.

A number of reasons for the checking have been advanced from time to time and a few are here enumerated. In the first place, it should be understood that a mass of concrete shrinks in drying, and swells as it absorbs water. The total range in linear change from dry to wet conditions is, for common mixtures (say about 1:2:4) approximately one-twentieth to one-tenth of one per cent. A mix richer in cement will experience greater changes, while one leaner in cement will show less change. Any condition which will cause one portion of the road surface to dry more rapidly than the adjoining portions will effect checking in the more rapidly dried part. The more important factors in producing non-uniformity in drying are:

1. Non-uniformity in the mixture. This may be caused by improper mixing in the mixer, which will result in variation in the consistency and in the richness of different portions of the batch.

2. The use of too much water in mixing, which is likely to produce variations in the consistency of the mass.

3. A prolonged working of the surface of the road, thus bringing to the top a rich mortar of fine sand which will shrink more than the leaner concrete beneath it as drying progresses.

4. In cool weather, and with cements which are slow in hardening, the rapid evaporation by dry wind.

5. Rapid drying due to direct exposure to the sun's rays.

6. A dry subgrade of variable absorptive capacity, or a subgrade which swells materially when wetted.

7. The use of an aggregate which contains particles varying widely in absorbtive capacity. For example, in one instance it was reported that a limestone aggregate caused shrinkage cracks, whereas the use of a gravel under exactly similar conditions did not produce this effect.

8. The use of dirty aggregate.

9. The use of a very quick settling cement.

Any one or several of the above may be contributing factors in the checking of a pavement. In most cases several of the causes listed above work together to form the hair cracks. Probably the most important contributing factors in checking are the first three listed. It is doubtful whether No. 7 is as important as our first thought might lead us to believe. No. 6 may exert a considerable influence in some localities. The only protection against checking is the elimination of such factors as are under control of the engineer. Sometimes the elements play a part and it is practically impossible to take any corrective measures.

ELECTRIFICATION OF ILLINOIS CENTRAL RAILROAD AT CHICAGO

By C. M. Ripley, General Electric Company, Schenectady, N. Y.

More than 100 miles of track in the suburban system of the Illinois Central Railroad at Chicago have been electrified. Twenty miles are double tracks, 9 miles have four tracks, and nearly 4 miles have six tracks—besides 4½ miles of single track.

To anyone who has been in Chicago—downtown along Michigan Avenue, or on the South Side—the familiar sight, sound and smell of rushing suburban steam trains cannot be easily forgotten. These trains parallel the lake front and come right into the downtown section carrying their precious freight of 25,000,000 human beings between home and work, between residence and theatre—25,000,000 people yearly!

What a blessing the new fast, smoke-

less, sootless, steel trains will be—not only to the millions of passengers, but also to those living en route—in houses, and in apartments or working in offices —with the trains passing under their very windows!

The beautiful skyscrapers facing the lake front will not need to be washed as often, because of the reduction in coal consumption by tens of thousands of tons. Lace curtains in the homes, and desks in the offices—they likewise will be spared, not to mention linen collars and pretty dresses.

Picture in your mind, scores of trains of new steel cars, silently speeding over the rails at the very edge of great Lake Michigan—gliding along at 55 miles per hour with 1,000 passengers; and see them reading their evening paper by brilliant electric light, sitting comfortably in electrically heated cars in the winter, enjoying the lake breezes in the summer! It is probable this will prove the most popular ride in America—a cool sightseeing trip along the lakeside, after supper on a hot August night, for thousands who otherwise would be sweltering in the heat of that superbly energetic Metropolis of the mid-west—Chicago. This ride is cheaper than a taxi, safer than a privately owned auto, more comfortable than a bus, faster than a street car, and cleaner than any other vehicle imaginable.

The Illinois Central electrified zone is not underground. It is an open air line with sun and air and lake breezes; and adds to the healthfulness of Chicago.

But, from the engineering standpoint, it is something like the New York subway, as there are no locomotives to haul these suburban trains. Every other car is a motor car with 1,000 horse power, and each alternate car is a trailer, all are steel construction, electrically heated, and each seats 84 people.

It is difficult for a passenger to tell which is a motor and which is a trailer, except for two pantagraph trolleys which are installed on the roof of each motor car. One pantagraph is used regularly, and the other held in reserve for emergency.

The first 260 steel cars have already been built; 130 of these are motor cars with 1,000 horse power, having four electric motors of 250 horse power each. The motor cars in the New York Interborough Subway are equipped with but two motors, the average size of each being less than 200 horse power. So in general, the power of the Illinois Central trains is very much greater than those of the Interborough.

For instance, a ten-car train has 5,000 horse power and with about 1,000 passengers, accelerates from a dead stop to 15 miles per hour in ten seconds, and in only ten seconds more is hitting 28. This pick-up, as auto owners know, is a timesaver and is especially valuable for railways where many stops are made on each trip.

And now as to the source of the electricity for driving these trains. The Illinois Central has contracted with the Commonwealth Edison Company of Chicago for this current. The electricity is made in existing power plants by steam turbines—those wonderful steam-electric machines having only rotary motion. Engineers estimate that for each additional ton of coal burned by the Edison Company, the Illinois Central saves 3½ tons. In other words, the ratio is estimated to be 2 to 7 in favor of the electric system, as compared with the old steam locomotives.

There was, of course, much romance to the old roaring steam locomotive, especially at night with the red gleam from the fire box illuminating the smoke and steam above; and in the day the rapidly rotating wheels with the piston rods and connecting rods dashing back and forth —they have never ceased to fascinate youth. But, is there no romance in the electric trains that have only rotary motion, fed by steam turbines with only rotary motion?

Ages ago, the sun blazed and made coal; now it is burned in smokeless boilers and its energy turns the big turbines which make the electricity; and this electricity is controlled, transmitted, subdivided, distributed and fed into a copper web spun out along the lake shore at Chicago, fed to the electric trains to make 25,000,000 people travel faster and be happier, safer and healthier.

What a sensation on Michigan Avenue Boulevard if 5,000 horses were driven down that great business thoroughfare; yet that is what virtually will occur each time one of the new 10-car I. C. trains pull in or out of the business section of Chicago. One of the main differences, however, is that this energy is silently conveyed underground by copper cables from the big power plants on the water front.

How long would it take to harness 5,000 horses? Assuming them already

harnessed and waiting, think how they would tie up traffic, because four abreast, they would stretch over three miles of the city's streets.

However, without any excitement, delay, this amount of energy, 5,000 horsepower, is delivered not to one train, but to many different trains along the Illinois Central Suburban Lines continuously night and day.

It requires no cracking of whips, no yelling or swearing of the driver—merely the operation of a controlling lever—for the clear-eyed engineers or motor men to corral and harness their 5,000 electrical horses and bring him to a speed of 55 miles an hour.

In the electrical industry alone there is a field of romance more interesting than the tales of bygone days. America needs a Kipling or a Jack London to describe properly the electrical developments and wonders of the 20th Century, and not the least fascinating story could be written about the $8,000,000 improvement of the Chicago Terminal of the Illinois Central Railroad and its electrification.

HIGHWAY RESEARCH IN TEXAS

By Doak Rainey, Assistant Highway Engineer, Texas State Highway Department

(From "American Highways" for July, 1926.)

During the year 1926 the Highway Department of Texas has carried on a limited amount of research along two lines: First, limestone rock asphalt, and second, concrete paving.

To understand the need of some of this work it is necessary to know something of the conditions that Texas has to contend with in the matter of roads.

Texas has about 200,000 miles of public roads, and of this about 11 percent, or nearly 22,000 miles, are State highways. The climate of Texas is almost as diverse as that of Maine and California. The southern portion of the State is almost tropical. It never freezes and very high temperatures are common in the summer. The eastern portion of the State has upwards of 60 inches of rainfall, whereas in some parts of the western portion of the State it practically never rains. In the Panhandle section the summers are very long and exceedingly hot; temepratures of 114 in the shade are not uncommon. The winters, although short, are very severe. Temperatures as low as 30 degrees below zero occur almost every winter. It is not uncommon to have a temperature of 60 or 70 degrees on one day and below zero on the next.

On account of the extreme heat of the summers throughout the entire State ordinary asphalt mixtures, as used in most northern and eastern States, have proven unsatisfactory in Texas.

One of the most satisfactory asphalt pavements we lay in Texas is limestone rock asphalt. This material comes from Uvalde County, in the south central portion of the State, and for this reason it is commonly called Uvalde Rock Asphalt. This material consists of from 85 to 95 per cent soft, porous limestone rock and from 5 to 15 per cent of bitumen. We ordinarily specify that the bitumen content used in road surfacing shall be from 8 to 13 per cent. We frequently use the leaner material for black base. This rock asphalt, as it comes from the mine, has a penetration of about 8 but is very ductile, practically all samples showing a ductility of more than 150. On account of this low penetration it is necessary to mix a flux oil with the rock asphalt. The rock asphalt is crushed to a fineness of about one-fourth of an inch and is placed in an ordinary concrete mixture drum revolving about 18 revolutions per minute and is sprayed with hot flux oil. After it is thoroughly mixed, it is placed on the road, raked smooth and rolled. The pavement is immediately ready for traffic. This material is laid in depths of from ¼-inch to about 3½-inch. This pavement closely resembles, both in quality and appearance, sheet asphalt.

During the past year the University of Texas laboratory, acting under the direction of State Engineer of Materials and Tests, have been conducting a series of experiments on this material in an attempt to determine the most satisfactory mixed rock asphalt and flux oil to suit the climate. We have found that altogether different treatment is necessary for the southern portion of the State, where we have no cold weather, than from that needed in the northern part of the State, where we have extremes of heat and cold. We have not yet found a satisfactory method of using this material in the eastern portion of the State, where we have heavy rainfalls. The greatest difficulty we have in the Panhandle section is to prepare the mixture that will not push or shove in summer and yet will not alligator in the winter.

During this year we will probably make as many as a thousand specimens of fluxed rock asphalt in an attempt to determine a mixture that will satisfy these conditions.

In connection with the Bureau of Public Roads the State Highway Department is building a section of concrete road about 10 miles long, upon which we are trying a great number of experiments, the chief of which are subgrade treatments of various kind. This section of road runs through heavy black, waxy soil, a class of soil with which we have had a great deal of difficulty with our concrete pavement in the past. Upon this soil we are trying gravel in varying thicknesses, sand in varying thicknesses, and lime as subgrade treatment. In the same section of road we are trying two or three admixtures and we are also trying calcium chloride as a curing agent alongside wet dirt and ponding. The reason for this being that we have had very poor results in this State in the use of calcium chloride. We are, therefore, endeavoring to find out whether or not the climatic conditions or the method of using is at fault.

The Bureau of Public Roads is conducing on this same section of road a study in an attempt to speed up work and thereby reduce prices. At the same time they are making experiments to determine the shrinkage of the concrete and paving.

During the past year the State started construction of 4½ miles of experimental road in Bell County. This work was finished early in the year 1926. This road, which is called "The Invisible Track Highway," consists of four concrete or brick tracks, heavily reinforced and separated by asphalt macadam. These tracks are so spaced as to form wheel ways for vehicles. The asphalt macadam is elevated very slightly. At uniform intervals drains are provided to get rid of the water.

HIGHWAY RESEARCH IN CALIFORNIA

By R. M. Morton, State Highway Engineer, Sacramento, Calif.

(From "American Highways" for July, 1926.)

In a State nearly 300 miles wide and 900 miles long, including within its limits the widest ranges of climatic and topographic conditions, it is desirable that studies for the development of the highway building science be carried on in the various divisions, each of which is confronted by problems peculiar to its own local conditions, as well as in a headquarters laboratory and research department. It has, therefore, been the policy of the Highway Commission to encourage such activity throughout the organization, and a review of progress made must in fairness give credit to those who have carried on the work. It is not easy to distinguish between studies and experiments which should be dignified by the term "research," and these might fall without this classification; therefore no segregation will be attempted; instead merely a brief outline of recent developments in construction and maintenance practice.

Grading Operations

Considerable study has also been given to the problem of establishing methods by which swell and shrinkage in embankment materials may be more accurately predetermined instead of leaving this important consideration of roadway design depending entirely upon the opinion of the engineer on the work. Progressive studies of the angle of repose of different materials in cuts and fills is also under way.

Center Joints

In concrete paving several types of transverse and longitudinal joints have been tried out during the year under the supervision of the Construction Department. These experiments have included the modified tongue and groove metal joint (Illinois type), an asphaltic center joint, a wood-strip joint, and weakened plane joints.

One of the most promising developments in a longitudinal joint is the weakened plane joint brought out under the direction of Mr. S. V. Cortelyou, Division Engineer at Los Angeles. This joint is made by attaching a "V" shaped block to the tamper on the tamping and finishing machine for driving rock down from the surface of the concrete along the center line. After pavement is partly finished, a groove is cut along the center line, using a template with a "V" shaped marker on the bottom surface. The joint is afterwards finished with a long-handled jointer ,and the final result is a uniformly straight center line groove cut about 1½ inches, deep and having adjacent depressions ¼-in. deep and 4-in. wide. This reduction of thickness on the center line results in the longitudinal

crack forming in the groove. The groove is sealed with asphaltic cement, which also flows out into the adjacent depressed strips and serves as a traffic guide line. On work which is thickened to 9 ins. along the center edges a wooden parting strip ½ by 5 ins. is placed vertically on the subgrade along the center line. The "V" joint is later made over this parting strip and the 2½-in. layer of concrete between bottom of groove and top of parting strip breaks readily to the groove without tendency to sprawl. This type of joint has been found to be very satisfactory on several projects.

Concrete Design

The Testing and Research Department is a branch of the Construction Department and closest co-operation is thus assured between field and laboratory. Mr. Pope, Construction Engineer, and Mr. C. L. McKesson, Materials and Research Engineer, have developed practices in the design of mixtures and control of concrete during the last year which resulted in average compressive strengths of 4,300 pounds per square inch for several thousand 6-in. by 12-in. concrete field specimens. The increased strengths reported have been secured without selection of cements nor increasing the quantity of cement used, which is fixed at six sacks per cubic yard in California State Highway specifications.

Asphalt Surfacing

In asphalt surfacing practices an important development has been the elimination of the asphaltic seal coat on bituminous concrete pavements and the reduction of asphaltic content to the minimum. Extensive use is also being made of asphalt surfaces carrying a high dust content.

Studies by Research Department

In order that the benefit of completed and partially completed researches may be available to others, it has been the policy to publish results and progress reports on research work in "California Highways," the official publication of the California Highway Commissions. Following is a list of researches reported within the last year with date of publication in "California Highways":

Rock Shoulder Material Tests, June, 1925.

Subgrade Treatment, Solano Lateral, August, 1925.

Reasons for Differences in Strength on Two Paving Projects, October, 1925.

Quick Hardening Concrete, November, 1925.

Curing of Concrete, January, 1926.

Concrete Mixer Studies by Pope and McKesson, February, 1926.

Selection of Rock and Gravel for Highway Work, April, 1926.

Culvert Investigation

The major study of the year in this department is an investigation of culverts of all types with particular attention being given to corrugated metal with the idea of determining most economical types and factors affecting life and efficiency of culverts. Over 5,500 culverts were inspected in the field and several hundred metal samples were taken. The data collected is now being studied, and a report will be completed within a few months.

Maintenance of Highways

Maintenance work is carried by the divisions under the general supervision of G. R. Winslow, Maintenance Engineer.

The principal study and experimental work reported by this department during the year has had to do with dust prevention on gravel roads.

Calcium Chloride for Dust Laying

Mr. H. S. Comly, Division Engineer at Redding, and Mr. R. E. Pierce, Acting Division Engineer at Sacramento, have used a considerable quantity of flake and liquid calcium chloride during the year in surface applications. The benefits have been quite marked where the salts have been used, but the treatments must be kept up from year to year. Mr. Comly's observations were published in the January, 1925, issue of "California Highways." Magnesium chloride has also been used by Division Engineer John H. Skeggs with results similar to those obtained with calcium chloride. The cost of treatment of a 20-ft. surface with either of these hygroscoptic salts is about $900 per mile first year and $300 per mile during subsequent years.

Oil for Dust Laying

Oil is also being used as a dust preventive. Very light applications of fuel oil, one-tenth to one-seventh gallon per square yard, tend to reduce dust nuisance. The cost of this treatment is reported by Mr. Pierce as $100 per mile for one application on a 16-ft. roadway. Two applications are usually necessary for the first year.

Traffic Guide Lines

A marker for painting traffic guide lines on concrete pavement was developed by Foreman Hugh Henry in the Los Angeles Division. This is a very efficient marker and is described in detail by I. T.

Voorhees, Division Maintenance Engineer, in the January, 1926, issue of "California Highways."

Control of Drifting Sand

Imperial County has a sand hill desert region in which moving sand dunes persistently bury the highway. Mr. E. Q. Sullivan, Division Engineer, has experimented extensively in an attempt to control the dunes by directing the air currents. Pot holes and trenches cut in the dunes have proven partially successful as a means for directing air currents. Small-sized model dunes were constructed in the Division Office and the study of the behavior of sand in air currents produced by electric fans was found to be of value in checking up on probable behavior of dunes in the field.

As a result of these studies, it has been possible to remove dunes containing thousands of yards of sand through the assistance of wind action at a minimum expense to the State.

HIGHWAY RESEARCH IN NEW JERSEY

By G. Roland Moore, Assistant Construction Engineer, New Jersey Highway Department

(From "American Highways" for July, 1926.)

During the past year the New Jersey State Highway Department has conducted a "Deterioration Survey" of all durable pavements constructed on the State Highway System during the past eight years of administration of this department by a State Highway Commission.

This survey consisted of the location, extent and nature of all classes of deterioration evident in the pavement proper on State highways, and the plotting of same on plans showing the construction conditions. It is the purpose to classify the information so obtained and reduce the amount of the various kinds of defects per mile of pavement, having in view the idea of arbitrarily rating the condition of each mile of pavement or any desired grouping of sections of pavement.

This information, combined with other available data in the departmental records, including maintenance costs, traffic records and sub-grade conditions when the pavement was constructed, will be used to compare the effectiveness of the various variable features of design and construction which have been used, particularly in concrete pavements, during the eight-year period. It is hoped that the facts accumulated from compilation of this data will serve as a basis for comparison of the effectiveness of such features of design as

(1) Heavy versus light reinforcement.

(2) Crushed stone versus washed gravel aggregates.

(3) Variable proportioning of similar aggregates.

(4) Effectiveness of varying methods of construction and location of joints.

(5) Varying proportions of pavement cross-sections, etc.

Design of Concrete Paving Mixtures

This investigation, now being conducted in the laboratories of the New Jersey State Highway Commission in cooperation with the United States Bureau of Public Roads, has for its object the determination of the most economical proportions to produce concrete of a given quality using various gradings of stone and gravel aggregates.

Thirteen gradations of each type of coarse aggregate are being made into concrete of various proportions. The specimens selected for test are 8-in. by 8-in. by 48-in. beams, on each of which two modulus of rupture determinations will be made using the Cantilever system of loading; 6-in. by 12-in. cylinders will be tested for compressive strength. The yield is being measured on each batch of concrete to determine the variations in the amounts of concrete produced by the several sizes of coarse aggregates.

The concrete is being proportioned in various ways. In method A, the several aggregates are combined by volume using the New Jersey standard proportion for concrete surface pavement. The consistency of the concrete as measured by the flow table is kept as nearly as possible the same for all aggregates. In method B, various ratios of sand to stone are being employed but the water cement ratio and consistency of the concrete are the same for all aggregates and combinations of aggregates. In method C, the various aggregates will be proportioned in accordance with the fineness modulus theory in an effort to produce concrete of a predetermined strength.

It is hoped that the data obtained will answer the following questions:

1. What relative strength and yield is obtained with stone concrete as compared to gravel concrete mixed in the same proportions and to the same con-

sistency, and with the same size of coarse aggregate?

2. Assuming a constant strength and constant degree of workability, what grading of coarse aggregate and what proportions of fine to coarse will give the greatest yield of concrete for both crushed stone and gravel?

BUS AND TRUCK REGULATIONS IN IOWA

By Dwight Lewis, Chairman, Iowa State Board of Railroad Commissioners

(A paper read before the Western Society of Engineers, April 21, 1926.)

With the establishment of gravelled roads and paved roads, there appeared occasional bus lines or truck lines between some of our larger cities and smaller ones nearby. The conditions were so chaotic, service so unsatisfactory ,menace to public safety so great, that the legislature in 1923 gave the Iowa railroad commission the authority to issue franchises or what were called certificates of operation to motor carrier applicants upon a showing of public convenience. There was also a tax fixed based upon tonnage at the rate of one-eighth of one cent per ton per mile when pneumatic tires were used, or one-fourth of one cent per ton per mile for vehicles with solid tires. This has been amended since and the road mile tax has been made double this figure.

The boards of supervisors of the various counties have complained bitterly that the tax provided for did not compensate for damage done to highways, and the Iowa Commission has several times recommended that careful and elaborate tests be made to determine just the measure of damage caused by these vehicles, and have the charge for the use of the highways or the tax for the use, based upon such actual figures. This has never been done and dissatisfaction still continues, the motor carrier operators declaring that this ton mile tax is too high while the county authorities in charge of highway improvement and maintenance are complaining such rates are too low.

The law of 1921 was declared unconstitutional in that it required the users of oil trucks to pay the license fee while exempting the trucks carrying farm and dairy products.

Commission Given Jurisdiction Over Rates and Service

The legislature of 1923 sought to remedy the defects found to have existed in the previous statute and as already stated, also doubled the tax rate, gave this commission additional power including jurisdiction over rates and service, and while the former statute had made the taxes payable to the various counties in which the carriers operated, the new law provides that such taxes shall be paid direct to the railroad commission which shall retain 20 per cent for the maintenance of the motor carrier department, the balance to be turned over to the state treasurer to be allocated to the various counties through which the motor carrier operates on the basis of miles run.

This law has also been called in question by a number of the motor carrier operators in Iowa because it only applies in its taxation features to public carriers of freight or passengers operating between fixed termini and over a regular route, complaint being made that it is special taxation and the taxes provided for are not uniformly assessed.

We have in Iowa at the present time 121 motor carriers operating 163 routes, 77 of which are passenger carrying routes aggregating, 3,486 miles, while 86 are freight carrying routes aggregating 2,511 miles. These figures are approximately accurate.

Granting Certificate of Operation

The new law provides that a certificate of operation may not issue to an applicant without a showing of public convenience and necessity, the words "and necessity" having been added to the previous requirement. There were certainly many varieties of bus and truck operators in Iowa when the first law became operative in April, 1923, and the law provided that all of those operating at that time were to receive certificates without a showing. There are still a few of these original operators but not many. Most of them were using old second hand cars and buses or trucks that were about through and when these finally collapsed there was no capital with which to continue the business.

The board now requires a showing from applicants as to character and financial responsibility in order that the public may be assured of continued servive, should the commission find from the showing made that the public convenience and necessity demand the serv-

ice proposed, and a higher type of operators are gradually entering the field. While it has been a veritable nightmare to attempt to bring order out of chaos and establish a real public regulation over a business that had been so carelessly operated, we feel that the skies are clearing and that we shall have in Iowa within the next twelve months real and substantial control.

Cancellation of Certificates of Operation

We have had difficulty when attempting to cancel certificates for non-observance of law or rules, because of the court's interference restraining the commission from enforcing its orders, and while we are not finding fault with this effort to protect the operator, it has affected seriously the respect for authority which any regulating body must have in order to function properly. However, a number of unsatisfactory operators—unsatisfactory because of their failure to pay taxes, failure to observe laws requiring stopping at railroad crossings, paying of insurance, keeping up the physical condition of vehicles—have ceased operating, their so-called franchises having been transferred to other and more responsible parties with the board's approval. We believe now that we may with some assurance of success require the keeping of accounts in standardized form so that we may know just what the financial results are from the operation of the various lines. It has been a serious doubt in our minds whether many of the lines operating were operating at a profit. Eventually, operation at a loss would mean cessation of service, and we believe it part of our duty to, if possible, preserve the service for the public. There have been too many cases where young men with a little money saved up have purchased with a first payment, a truck or a bus, only to find that their income was insufficient to provide for replacement, depreciation and pay current expenses of operation. We hope by our standard of accounts not only to preserve service to the public but to protect operators in the management of their own business.

Bus and Truck Service by Railways

Some of you may recall that at Atlantic City a few years ago I strongly insisted that our rail lines, both steam and electric, should establish auxiliary service by both bus and truck, that the public was demanding this service and if the transportation lines already organized did not provide such service, others would; and that the public, no matter what we might think of its judgment, would get what it wanted, regardless of protest or artificial barriers erected by legislation or excessive taxation. I fear my advice fell upon deaf earns for in our our state, at least, the electric interurban lines have only recently been supplementing their rail service by the use of motor buses.

Our electric interurbans are now conducting splendid bus lines which have given us no trouble whatever in so far as obedience to laws, payment of taxes, and reliability of service. While I have no figures to quote, it is reported to me generally that this auxiliary bus service is making a satisfactory showing financially and is pleasing the public.

My own position is that wherever a rail transportation company desires to augment its service by the use of buses or trucks, or to extend its service for the public by new routes for buses or trucks, they should be permitted to so operate upon showing of course as provided by the statute, regardless of whether there is other bus or truck competition. I take this position because I believe that the public is more certain of service and is entitled to the best service obtainable. In Iowa none of our steam lines has added an auxiliary bus or truck service, although many lines in the East particularly are beginning to provide such service.

Long Haul by Buses

While we may have thought that the bus was reserved for the short haul, I was amazed recently to find in Kansas City a busload of passengers coming in from Denver, having been about 24 hours on the way, and that there is a regular service between Kansas City and Los Angeles. I do not believe such travel will ever take the place of through transportation on our great transcontinental railroads unless perhaps there should be a revival of the old stage coach days when people travelled more leisurely and became more acquainted with the country they traversed. It is possible there will be a reaction against the swiftness of modern travel and a desire to see our great continent in a more leisurely fashion. However, this all may be, we are certainly passing through a transition period in transportation, the outcome of which I would not hazard a guess. I do not believe there is any prospect in sight that our great railroad companies are to be seriously impaired, either in service

or in revenue by the advent of bus or truck lines, although undoubtedly tremendous changes are taking place in the handling of short hauls, both passengers and freight.

Requirements of Iowa Law

The present Iowa law provides that it shall be unlawful for any motor carrier to operate or furnish public service without first obtaining from our Commission a certificate declaring that public convenience and necessity require such operation. A public hearing must be held, previous notice of which is given by publication. The cost to the Commission of such hearing must be paid for by the applicant. Anyone may make objections to the granting of the certificate and upon a decision anyone, party to the proceedings, may appeal to the court. No certificate of operation may be transferred without the Board's approval. Before a certificate is issued at all, the applicant must file with the Commission a liability insurance bond in a form approved by the Commission and issued by some company authorized to do business in Iowa. This bond shall be in such sum as the Board shall determine will reasonably protect the travelling or shipping public. We have fixed the bond so that for instance a passenger vehicle with a capacity of from 21 to 25 persons must carry a bond of $25,000; other size vehicles in proportion. No motor carrier shall be permitted to operate upon the highways with solid tires which together with its maximum load weighs more than 7 tons. If equipped with pneumatic tires the gross weight shall not exceed 9 tons. Cities and towns regulate the operation of motor vehicles within the corporate limits except that the board of railroad commissioners exercises jurisdiction over all the mileage as to taxes, service, etc. The law requires that every motor vehicle and all its parts shall be maintained in a safe and sanitary condition, always subject to inspection by the Commission or its representatives. Every driver employed shall be at least 21 years of age, in good physical condition, good moral character, fully competent to operate, and in addition shall hold a regular chauffeur's license from the State Motor Vehicle Department. Passengers shall not be allowed to ride on the running boards, fenders, or any other outside part of the vehicle. All motor carrier vehicles shall stop at railroad crossings, and the speed is limited upon the highways to 30 miles per hour for passenger vehicles and 20 miles for freight. Accidents shall be reported promptly to the Commission, and each motor carrier vehicle shall have such distinctive marks or tags as shall be prescribed by the Board. For violation of any provisions of the act, the Commission may revoke and cancel the certificate and in addition to this, or aside from this the owner, officers, agents, or employees of any such motor carrier who violates or fails to comply with any provision of this act, or the rules and demands of the Board, shall be guilty of a misdemeanor and upon conviction shall be punished by a fine not exceeding $1,000 or be imprisoned in the county jail not exceeding 1 year, or by both such fine and imprisonment. In addition to these requirements of the statute, the board may make other rules and regulations, which it has done, and but recently issued its revised rules of 1926, the effective date being made as of March 1st. The statute also provides that the Board is vested with power and authority to require periodic inspection of any equipment, to fix or approve rates, fares, charges, regulate and supervise accounts, schedules, service and safety of operations, to provide a uniform system of classification of accounts which must include a proper setting up of depreciation charges, to require annual and other reports ,and in so far as possible have such control over motor carriers as the Board now has by law over the operation of railroads and railroad companies. The law also provides that all rates shall be just, reasonable and non-discriminating. All other rates are declared unlawful.

Rules of Railroad Board

The rules which the board has promulgated include the requirements made by statute and in addition provide how tariffs shall be printed, where posted; how schedules of operation shall be arranged for and their posting; and that no changes shall be made in schedules of operation or rates except by giving 30 days' notice. Rates and schedules may be put into effect on less notice with the approval of the board. The rules provide that if two tires of the vehicle are solid, taxes shall be computed upon the basis of solid tires. The board's rules also provide that extra parts, tools, inside lights, windshield wipers, non-skid tire chains and extra tires shall be provided. A new rule has just been adopted which provides that no motor carrier operating any motor vehicle used in transportation of passengers or property,

shall cause or allow any driver or operator of such vehicle to work as a driver or operator for more than a maximum of 12 driving hours in any 24-hour period and such driver or operator shall have at least 8 consecutive hours' rest in each 24 hour period. Every motor carrier vehicle must be provided with red flags and lights. No motor carrier operator shall knowingly carry in vehicle transporting passengers any high explosives, acids or inflammable liquid or article which will endanger life or limb. Gasoline tanks must be on the outside of the passenger compartment and must not be filled while the engine is running. Oil stoves shall not be burned in any passenger carrying vehicle while such vehicle is in motion. There shall be provided in each motor bus a fire extinguisher approved by the Underwriters Laboratories, Inc. Our rules also provide for available exit doors and speedometers, and that passengers shall not be permitted to board or alight from vehicles except on the right hand side nor until the vehicle has come to a full stop. The motor carrier tax law provides that if the tax is not paid promptly a penalty of 25 per cent of the tax is added for such delinquency. If payment of taxes is not made on or before 60 days from the date when the tax is payable, the property of the carrier, or so much thereof as may be necessary, may be sold to satisfy the said taxes and penalty, interest and cost of sale. In connection with this provision of law, the board's rules also provide that upon such 60 day delinquency, "the board will consider that the motor carrier is not financially able to properly operate, and the certificate of Convenience and Necessity held by such motor carrier will be revoked."

Administration of Motor Carrier Law

Our commission has tried hard to administer the motor carrier law fairly and impartially with rather unsatisfactory results. Many bus and truck operators insist that we are partial to railroads and that it is hard for them to get a square deal because of our sympathy for the rail carriers, while at the same time the representatives of the railroad companies and railway trainmen, I fear, feel that we disregard their strenuous objections and thereby show favoritism toward bus and truck lines. It is not always easy to know to which side of a controversy to give the weight of judgment when both the applicants and the objectors have about an equal number of prominent citizens for and against the proposed service, some claiming a public need and other declaring there is no such need. We have taken the position generally that where objection is made to a proposed line there must be an unusually strong showing as to public necessity and convenience to warrant the granting of a certificate. If it is shown there is ample and convenient rail service, such testimony is hard to be overcome, and we have turned down many applicants for certificates of operation because of adequate present service. While the service of the motor carrier on the public highways is comparatively new ,it is going to be difficult to determine just its real place in the economy of transportation. It will be found, however, and this method of public transportation will eventually fit into its proper place with the least jar to established institutions.

An application recently heard by me excited the opposition of three railroad companies. It was shown, however, in testimony that in order to reach the three towns which this motor carrier of freight proposed to serve from a large distributing center, it took from three to five days to carry goods by train, while to the same towns over good highways the time consumed by motor carrier would be from three to five hours. The service proposed paralleled no railroad but did open up these three communities to this distributing center, which otherwise could not compete for business in these towns. It has been my thought that with the coming of hard surfaced roads the bus and truck business as public carriers may be profitably handled and in large measure should be auxiliary and feeder service for our railway systems. I do not know, of course, whether this will involve the eventual abandonment of the short branch lines or feeder lines but such a situation would not surprise me at all.

Personally I do not see why anyone would want to take a long continuous non-stop trip by bus but evidently there are many who do; and this may mean a serious inroad on the tourist travel on our railways. That situation is just developing. It may prove to be so unprofitable that it will not get very far. The National Assocation of Railway Commissioners is urging the passage of a bill by Congress providing for the regulation and control of motor buses and trucks acting as common carriers of interstate

business. There is no legislation affecting that feature of bus and truck operation, and we are hopeful that Congress will pass the bill.

SEWAGE PLANT AT NEW ROCHELLE, N. Y.

A new sewage disposal plant, just completed for the city of New Rochelle, N. Y., by the Tuller Construction Company (Fuller and McClintock Co., Inc., engineers), is capable of handling a maximum of 20,000,000 gal. of sewage per day, (although the plant is a comparatively small one. The plant is electrically operated and involves an interesting arrangement of motors and control.

In the case of a flood or very severe sewage conditions, the sewage can be by-passed into the bay direct. The sewage enters the plant through a hydraulically-operated valve near which is a bar gate which picks out the very large pieces of waste matter. The sewage then passes through either or both of two hand-operated gates into Dorr cylindrical screens which take out a large percentage of sewage matter and allow the water to flow into a large sump. The sewage is elevated to a compressed air ejector which blows it into another building whence it is hauled away to be used as fertilizer. The water in the sump is treated with a chlorine solution and then pumped into the bay.

The centrifugal pumps used to pump the water from the sumps are governed by a special General Electric control panel. There are two pumps, each driven by a 40-horsepower General Electric slip-ring motor. The arrangement is such that either motor may be operated manually or automatically, separately or simultaneously. The panel controlling the operation is automatically energized by means of five float switches, each one set at different water levels. When it is desired to operate automatically, either or both of the switches controlling the two motors are thrown to the "automatic" position.

The sequence of automatic operation is as follows: When the first float switch closes, the motors automatically accelerate to 80% of full-load speed and the water will be pumped at the minimum rate from the sump into the discharge line to the bay. Should the water in the sump rise faster than it is being pumped out, the second float switch will operate, bringing the pump motors to 85% of full-load speed. This continues as the water rises, each of the remaining float switches being actuated at its corresponding water lever, increasing the pump motor speeds to 90%, 95% and 100% of full-load. The operation is reversed as the water level falls, the motors automatically slowing down as the water reaches each float level.

At each speed of the motors a bull's-eye lamp is lit, indicating to the operator the speed at which the motor is running. When operating by hand, the control is first thrown to the manual position and, as soon as the "start" tumbler switch is closed, the panel automatically brings the motors to the 80% speed. The other speeds are obtained by throwing tumbler switches mounted on the board.

By adopting this method of speed control, the engineers found it possible to use a smaller motor and a smaller discharge pipe than would be required if the pumps were operating at the 100% speed only.

DUST PREVENTION ON GRAVEL ROADS IN MIDDLE WEST

By N. M. Isabella, Maintenance Engineer, Wisconsin Highway Commission, Madison, Wis.

(From a paper read at 1926 meeting of Mississippi Valley Conference of State Highway Departments.)

A canvass of eight central western states shows that the total mileage on their respective state systems is approximately 60,000 miles. Of this approximately 23,000 miles are surfaced with gravel. These highways, by virtue of being on the state systems, are naturally the more important ones and those which carry more than average traffic.

Needless to say, the dust problem on these highways is beginning to attract considerable attention and we find practically all states experimenting with various dust palliatives in trying to solve their difficulties. While there are thousands of miles of dirt road on the main routes that contribute to the dust nuisance, the remarks in this paper will be confined mainly to gravel roads. Experience has shown that when traffic reaches 500 or more vehicles per day on a gravel road, some form of surface treatment is necessary in order (1) to provide for safety; (2) to protect the original investment by conserving materials; (3)

to improve the efficiency of the highway.

The most common palliatives used thus far by the various states are calcium chloride, light asphalt road oils, light tars and medium asphalts.

Calcium Chloride Treatment

Calcium chloride has been used quite extensively by a number of the states in combating the dust nuisance. This type of treatment is fairly satisfactory, but it requires the regular patrol operations to keep the surface smoothed up at all times and requires also at least two treatments per season. Calcium chloride should not be used on gravel surfaces having a large clay content as the moisture drawn from the air would tend to make the surface slippery in the same manner as a shower of rain. In treating a gravel road with calcium chloride, the first thing to do is to properly shape the surface of the road to a uniform cross section. This is followed by an application of about ¾ to 1 lb. of calcium chloride per square yard distributed with an ordinary lime sower or similar device. This treatment should be followed by a second teatment of about ¾ lb. per square yard from a month to six weeks later. If the season should be an unusually dry one it may be found necessary to treat the surface a third time with a very light application. Experience has shown that approximately 2 lbs. per square yard per season works out very satisfactorily on the average gravel road. Some prefer two applications whereas others believe three applications using smaller quantities for each application are more satisfactory. This would mean that the cost per season for material and labor in applying the treatment would vary from 3 cts. to 5 cts. per sq. yd. The time and expense of the patrolman in daily patroling the surface should be included which would add approximately $150 to $200 per mile per year, making a total cost per mile of between $400 and $600, depending on width treated. The calcium chloride treatment is quite satisfactory in keeping the dust down and holding material on surface, but it has no permanent effect.

Light Asphaltic Road Oil

Light asphaltic road oils have been used to some extent on gravel roads but to a greater extent on dirt roads. It may be stated that this type of treatment will also keep the dust down and provide a satisfactory riding surface for a limited time. The oil also waterproofs the surface to the extent that it will shed water very readily during rainy spells. The one disadvantage in this type of treatment is that the surface will gradually become smooth and shiny in spots and as the oil evaporates the surface will start to disintegrate and thus cause a very uneven riding surface. This may be eliminated to a certain extent by keeping a light mulch of fine material on the surface at all times and grading it from one side to the other, thus preventing a crust from forming. Usually about ½ gal. of oil per square yard will suffice on the average gravel road. However, it often becomes necessary to make a light second application later in the season to preserve the original condition. The light oil surface treatment will cost approximately $350 per mile per year, plus the patrol maintenance cost which will bring the total cost per season between $500 and $600 per mile or about 4½ cts. to 6 cts. per sq. yd. Treatments the following year will require less oil per square yard and thus the cost the second year will be decreased slightly. The road should be scarified annually and it is very necessary that these treatments should be followed up from year to year if a uniform surface is to be maintained. If this is not done the surface will soon disintegrate and become very rough.

Light Tar Treatments

More miles of gravel road have been treated with light tars than with any other dust palliative except calcium chloride. In general there have been three methods employed: (1) that which provides a skin treatment where the penetration is less than 1 in.; (2) a treatment where a penetration of approximately 1½ in. to 2 in. is attained by mechanically mixing the tar and surface gravel with a grader and allowing traffic to compact the material; (3) where the surface materials are mechnically mixed the same as in case two, and a light roller is used to compact the treated portion. The first named treatment has been used a good deal in several states with considerable success, but that type of treatment requires annual scarifying, reshaping and retreatment. The surface will not usually go through the winter season without being broken up by winter traffic and therefore requires scarifying each spring.

The Skin Treatment

The skin treatment may be briefly outlined as follows:

The road to be treated is brought to uniform cross section and excess loose material is removed from the surface by

a power sweeper. After the sweeping operations are completed, the surface of exposed metal should present a mosaic appearance. An application of about 1/6 gal. per square yard is then applied with a power distributor. Tar may be heated not to exceed 125° F. to facilitate distribution and penetration. This is allowed to penetrate for at least 48 hours. No absorbent is used after the first application of tar. If traffic cannot be conveniently shut off it is allowed to move over it. The second application of about ½ gal. per square yard is applied from two days to a week later, this application being immediately followed with coarse sand or pea gravel. If the tar shows a tendency to bleed more sand should be applied. Within a few days traffic will gradually iron out this surface making it appear very much like a bituminous macadam or an asphalt surface. The penetration, however, is from ½ in. to ¾ in. Any holes that may appear in the surface are patched from time to time by material consisting of a mixture of 17 gals. of light tar mixed with 1 cu. yd. of coarse sand. This treatment has been used quite extensively in the states of Maine, New Hampshire and other eastern states with considerable success, but it has been found necessary to scarify and retreat each year. The annual cost will vary from 8 cents to 11 cents per square yard for the first year. Subsequent treatments will decrease slightly due to the fact that less tar is required in succeeding years.

The Mixing Method (Traffic Bound)

This method was especially devised to do away with the annual scarifying and retreatment operations and it is especially adapted to gravel roads having an inch or two of loose material on the surface. Under this method the road is brought to uniform cross section and it is quite desirable to have some loose material on the surface. An application of about ¼ to 1/3 gal. per sq. yd is then placed on the entire surface. The amount of tar will depend somewhat on the porosity and the absorbent power of the surface materials. Immediately following the first treatment, a large blade grader with blade set at an angle of approximately 45 degrees and at a depth of ¾ in. to 1 in. moves the material a few feet beyond the center of the road. The distributor immediately follows the large grader with an additional ¼ to 1/3 gal. per square yard. The material previously moved to the center of the road is then moved back over the freshly applied tar. The same operation is followed for the other half of the road and in order to get a thorough mixture of the tar and surface gravel the entire surface should be moved back and forth several times with the grader. After traffic has been allowed to use the road for a week or ten days, the necessity of a light seal coat may be easily determined. Usually the movement of traffic over the road irons out the surface to such an extent that some of the tar works up to the top and sufficiently seals the surface so that an additional treatment is not necessary. However, if it is found that the tar does not readily work to the surface a light seal coat followed with an absorbent of coarse sand is advisable. Extreme care should be exercised not to use too much tar, for if there is too much binder present the surface is apt to shove or wrinkle. With this method it has been found that a crust or mat of 1½ in. to 2 in. in thickness is built up. The amount of tar required varies from 2/3 to ¾ gal. per sq. yd. and the cost varies from 9 cts. to 14 cts. While experiments with this method have only been in service for two or three years, it is safe to say that under this treatment a reasonably smooth surface may be maintained for several years with but a light application every two or three years. The original cost per mile on an 18 ft. width is from $900 to $1,200 per mile. The succeeding years the cost will depend on the amount of patching necessary and this is usually very small if the original treatment was properly placed so that over a four or five year period the average cost per mile is cut down to approximately $600 or $700. It is unnecessary to scarify this surface each year as is the case with the skin treatment outlined above.

The one emphatic complaint that motorists have against oiling or tarring of any description is that their cars get spattered with oil or bitumen and this causes them extra expense and inconvenience. By treating a road under the mixing method this objection is practically eliminated, as traffic is allowed to use one half of the road while the other half is being treated. Experience has also shown that by immediately mixing the bitumen with gravel that the resultant mixture is not readily picked up by the moving vehicle but on the contrary traffic tends to compact the surface.

The Mixing and Rolling Method

This method is the same as the mixing

method except that instead of allowing traffic to iron out the surface, a light roller of not more than 5 tons in weight is used to compact the material. The advantage in this method is that the surface is smooth by rolling the entire width immediately after the mixing has taken place and traffic will not be inclined to follow the same rut. In other words, it will be distributed evenly over the entire surface whereas in the traffic bound mixing methods vehicles are inclined to follow the ruts of the vehicle that preceded. The cost of the mixing and rolling method is practically the same as the preceding method.

Medium Asphalt

Treatment with this material is somewhat different than with light tars but the resultant surface is practically the same. Usually it is applied in two applications about six weeks apart. After the first application a planer or drag is used constantly over the surface at the same time allowing traffic to iron it out. The second application is placed about six weeks later and is followed with a covering of coarse sand. While there have been but a few miles of gravel roads treated by this method in Wisconsin, it is believed that satisfactory results may be obtained with medium asphalt.

Conclusion

It has not been the intention of this paper to cover in detail the various operations in the surface treatment work, but on the contrary it is intended to bring out a few of the high lights and experiences of the various states in the central west. Surface treatments render a definite service to the road user as well as to the one who lives along the highways. The expenditures can be easily justified where traffic is heavy enough to warrant the treatment. This is especially true when you consider that on the average gravel road which has a traffic of 500 or more vehicles per day that the annual loss in material on an 18 ft. width is from 300 to 400 cu. yds. per mile. Figuring this at $2.00 per cu. yd. in place we would have $600 to $800 per mile loss in material each year if it is not surface treated. No community is so well supplied with materials that they can afford to lose this amount each year indefinitely. Even if the road will eventually be paved with a durable pavement, materials must be conserved for the secondary and local roads. In addition to making the saving in material there is elimination of the dust nuisance which has been responsible (1) for many of the highway accidents and insanitary conditions, (2) for deterioration of motor equipment, clothing, buildings, furnishings and farm crops, and (3) for decrease in efficiency of the highway. When you consider what this means on the many thousands of miles of gravel roads on the various state systems it is obvious that a surface treatment renders not only a true highway service but it is a sound business proposition. It does not take the place of a durable pavement but it bridges the gap between the plain low type surface and the durable pavement. It is a maintenance and not a construction problem.

MOVING SIX-STORY REINFORCED CONCRETE HOTEL

When the Hoosier State set itself to the task of constructing the Indiana World War Memorial Plaza at Indianapolis, it necessitated a gigantic engineering feat that will be unique in the annals of the commonwealth. This work, now underway, is the transfer of a six-story, reinforced concrete hotel from the park site to a new location 600 ft. distant by the little known craft of house moving.

The plaza is intended as a perpetual memorial to the sons and daughters of Indiana who served their country during the World War. Estimated to cost approximately $15,000,000 when completed, it stands the largest memorial project in the world today and the attention it is attracting throughout the United States and in foreign nations is expected to draw thousands of persons to the state.

The idea of the memorial originated with the American Legion at whose instance service men and women of the state sacrificed a proposed state bonus for its existence. Expenses also will be defrayed by Indianapolis, the county of Marion, and the state at large.

The plaza is located in the heart of the capital city just two blocks north of the "Circle." It extends for five city blocks, each block being about 250 ft. long, and will be one block or about 300 ft. wide. It is bounded on the south by East New York street ,on the west by Meridian street, on the north by St. Clair street, and on the east by Pennsylvania street. On it will go all war memorials and buildings to be occupied by memorial bodies. Two new structures that now occupy the site and are being

incorporated into the plan are the post-office and the library.

Buildings ordered removed were the Indiana blind institute, a historic structure erected in 1853, and two churches, all of which will be raised, and the Haugh Hotel now being moved. When found that it was next to impossible to wreck a reinforced concrete building, it was decided to move the hotel and the work was awarded to the Kress-Oravetz House Moving Company, a Pittsburgh concern.

Although its fundamentals are simple, said F. A. Fees, secretary of the company, the work of moving a building is a mystery to the majority of persons. That it is fascinating as well as mysterious is evidenced by the fact that it may be necessary to secure police protection to keep crowds of spectators from interfering with workmen on the Haugh project. Moving, Fees said, is a matter of picking a thing up, carrying it a distance, then setting it down whether it be a huge building or a piece of furniture but the methods are different.

The skill of the craft consists in lifting the structure in such a way that it will not slip and topple over or crack the walls. It also is necessary to move it over streets without incurring damage. To protect itself from this latter danger the City of Indianapolis has exacted a heavy bond.

The Haugh Hotel stands in Michigan street between Meridian and Pennsylvania streets. It will be moved into Michigan street, turned one-quarter to face east, taken down the thoroughfare, turned again and backed into its new location near the Medical Arts building.

The hotel is 45 ft. wide, 70 ft. deep, and 68 ft. high. When moved into the thoroughfare the structure will occupy all of the street and the greater part of the sidewalks leaving only a narrow gap between itself and buildings on either side.

According to Mr. Fees, it will require approximately three months to complete the work, the actual moving alone will take about three weeks. During this time Michigan street will be closed to traffic and when Pennsylvania street is crossed it will be necessary to cut street car wires. This crossing will take place in the dead traffic hours between midnight and five o'clock in the morning.

The hotel, with the temporary supporting I-beams, is estimated to weigh 3,000 tons. This enormous weight will be pushed into the air by means of about 600 giant 50-ton screw-jacks, without which there could be no such thing as house moving. Preliminary to the raising, however, comes the work of timbering the structure.

This consists in placing the supporting steel under the house in criss-cross fashion forming a sort of steel cradle. To do this, holes are punched in the foundation walls and beams inserted under the width of the building. Under these and supporting them in the Haugh Hotel will be six beams running the full length of the building. Bearing on these will be the screws, placed close together. The screw-jacks will rest on solid piles of lumber cribbing composed of 6-in. by 8-in. blocks, 40 ins. long. More than 100,000 ft. of lumber will be used.

The actual raising is accomplished by turning the jacks with steel handles. On a full turn each jack raises ⅝ in. The movers, working in unison, will start at the front of the building and give a quarter of a turn to each of the 100 screws in the six lines of jacks under the hotel. Thus when they have traversed the distance from front to rear the building will be 5/32 in. higher than at the start. This process is repeated until the required height is reached.

At this point the moving is started. Railroad tracks are laid and steel rollers placed upon them, then by means of winches and horse teams the building is pulled upon the rollers. In the hotel project 12 rails and more than 500 rollers will be used. Once on Michigan street the structure will be moved at a rate between 10 and 15 ft. an hour. When the new location is reached, the building will be rolled onto the foundation, and the lowering process, just reverse to the raising, started.

This Herculean task of changing the street address of a 600,000-lb. building is completed by removing the supporting steel and tieing the structure to its new masonry.

The Kress-Oravetz company has to its credit an achievement that stands alone. This was the moving of the birthplace of the H. J. Heinz Company, another Pittsburgh concern noted for its food products. The building, a two-story solid brick structure was loaded upon a barge and floated seven miles down the Allegheny river to the present factory site where it now stands as a symbol of the progress of the company. On the journey it was necessary to sink the barge by pumping water into it to go under a

bridge. This accomplished, "the house that took a boat ride" resumed its journey.

SAFETY CONSIDERATIONS IN HIGHWAY DESIGN

By Sidney J. Williams, Director Public Safety Division, National Safety Council, Chicago

(A paper read before the Western Society of Engineers, April 22, 1926.)

In considering the safety features of highway design we must first ask what the highway is to be used for. I refer especially to the width and the speed of the vehicles. As for width, most highway engineers have come to believe that 18 ft. should be the minimum and many advocate 20 ft. A 20-ft. roadway, however, is not safe for the newer type of buses, having a wide spread of the rear wheels, traveling at high speed (sometimes 50 or 60 miles per hour) and passing similar buses or other cars traveling in the opposite direction. For such traffic a 24-ft. roadway was advocated by the 1924 National Conference on Street and Highway Safety which added "whether this extra width should be provided at public expense to accommodate a relatively small number of vehicles operated for hire is an economic question outside of the province of this Committee." The report adds that if such vehicles operate on highways less than 24 ft. wide their speed must be severely restricted when passing other vehicles and that they should not be allowed to operate at all on less than an 18-ft. highway.

While the economics question just referred to was naturally dodged by this Conference, it cannot be dodged by our highway authorities who are here confronted with much the same sort of problem that has always confronted the designers of railroad bridges—namely, how much additional investment to make on account of probable future increases in sizes and weights. I do not pretend to answer this question other than by stating the belief that, after all, the highways are built for the traffic, and not the traffic for the highways; with the present trend for more, larger and faster buses, we must prepare somehow to handle them with safety to themselves and to other vehicles on the highways, and this means a clearance of at least 2 ft. between the edge of the tire and the edge of the pavement and more than that clearance between passing vehicles. Bridges especially should be made wide enough to care for future as well as present demands, with 22 ft. of clear width as a minimum and more if possible and, on long bridges, separate sidewalks for pedestrians or, at least, occasional safety zones outside of the roadway.

Many two-lane highways today are over crowded, raising the question of increasing the width to accommodate three, four or more lanes, or building additional parallel highways. This is not particularly a safety question except as to the three-lane highway. In common with most highway engineers I do not advocate the three-lane highway except in very special cases. Aside from any other considerations it is evident that on a highway where three lanes of traffic can move safely—say 27 or 30 ft. wide—four lanes can move unsafely, and frequently will. On a three-lane highway, lines on the pavement delimiting the lanes are particularly desirable.

Pavement Marking Promotes Safety

Pavement markings in general are being used more and more, and should be. I believe in the Illinois practice of center lines on straight-aways as well as on curves for I believe they add much to ease and safety in driving. In some of the eastern states, a contrary opinion is held, namely, that the center line should be used only on curves and in other places where the overtaking of another car is forbidden by law; that is, the motorist should know that he is never permitted to cross or drive on the wrong side of a center line. If this is to be the rule, then obviously center lines could not be used on straight-away because then there would be no overtaking. This matter was argued at length in committee meetings of the National Conference, two years ago, leading to the compromise decision that a white line should be used only at points where it is illegal to cross the line or be on the wrong side of it; that black lines may be used elsewhere, as on straight-aways.

In addition to center lines, other pavement markings are being and should be used more and more for both safety and convenience, to supplement signs by the roadside as a means of telling the driver what he is to expect or what he is to do. The National Safety Council has been making a study, not yet completed, of the extent and nature of the use of pavement markings both within cities and outside. Eventually, and the sooner the better, there should be some standardization of

the design and meaning of pavement markings, under proper auspices, and covering both city streets and rural highways, so that a certain marking will mean the same thing not only in different states but within cities as well as without. There is great need for engineering study and development of satisfactory permanent pavement markings inlaid or otherwise which will be cheaper in the long run than the frequent renewal of surface painting.

Speed Limits May Be Increased

For what speeds shall our highways be designed? With the developments in vehicle design and construction, highway speeds have been increasing and will doubtless continue to do so.

Some of you know that in the matter of automobile speeds within cities I have been among the persistent advocates of the enforcement of moderate speeds, for example, a prima facie limit of 20 miles per hour in residence districts. This is because, in cities, we have various conditions which cannot be altered nor certainly controlled—buildings and other obstructions to view, congestion of traffic, and most important of all, the ever present likelihood of some unexpected or careless action on the part of other users of the highway, drivers and pedestrians and especially children. Furthermore, we know that to relieve congestion and expedite traffic in a large city, what we need is not a higher maximum speed but a more uniform and therefore a higher average speed through the elimination of obstacles and delays.

On the open highway the situation is different. There, higher speed is really a boon to the motorist traveling a considerable distance; and speeds of 40 or 50 miles an hour may be perfectly safe, with a good car, tires in good condition, no pedestrians, a well built highway, and no obstructions to the view. With further advances in the reliabiltiy of cars and tires these figures may be still further increased. I do not wish to be understood as advocating any change for the present, at least, in the prima facie limit of 35 miles per hour on the open highway which is found in the laws of many states and in the model motor vehicle law recently developed by a representative national committee and adopted by Secretary Hoover's National Conference on Street and Highway Safety. But it seems to me that the occasions on which the prima facie limit may be exceeded with entire propriety, both legal and moral, are much more frequent on the open highway than in the city and that even assuming complete compliance with existing laws, speeds of 40 and 50 miles per hour must be reckoned with by the highway builder. I must add that the model law already referred to recognizes the present trend by providing that where a highway is made an arterial or through highway with stop signs at every intersection, the 35 mile limit may be increased by action of the local or other regulatory authorities.

This paper is not intended to be a discussion of automobile legislation nor of safe speeds and I have mentioned these only by way of pointing out that modern highways must be designed on the expectation of rather high speeds even at present, and with the likelihood that these will increase rather than diminish in the future. This means, obviously, generous widening and proper super-elevation of curves, together with transition curves, as already generally accepted by designers. It also means that the removal of obstruction and the providing of a clear view is of ever increasing importance.

Remove Obstructions to View

The distance along which an unobstructed view is necessary, depends directly on the stopping distance of, not the best nor even the average but the most poorly braked cars. Recent studies of the U. S. Bureau of Standards and others have shown that we cannot hope to enforce a higher standard for brakes than that corresponding to a stopping distance of 50 ft. from a speed of 20 miles per hour. A very large percentage of cars now on the highway, including a great many trucks, do not conform to even this standard. For a speed for 40 miles this means a stopping distance of 200 ft.; a speed of 60 miles means a stopping distance of 450 ft. Perhaps the latter may be disregarded because a car capable of 60 mile speed, with any sort of comfort to the occupants, is ordinarily a car equipped with good four-wheel brakes. But there are, and will be many flivvers on our highways doing 40 miles an hour, that would have a hard job to stop from that speed in 200 ft. Adding a like distance for the on-coming car and we see that an unobstructed view of 400 ft. at least, is necessary for safety, or 200 ft. each way from an intersection. These distances should really be increased in view of the likelihood of skidding and also to allow for the interval which elapses between the sight of the oncom-

ing car and the actual application of the brakes. Looking ahead five or ten years it is easy to foresee a time when a point of obstructed vision on a highway will either be the scene of numerous wrecks or will force such a slowing down as to constitute a serious "bottleneck." We shall have to spend more money, in the future, in the removal of obstructions, even trees and shrubbery of artistic value as well as sign boards of inartistic value; widening of cuts at curves and at intersections; the increasing of vertical radii at crests; and even the condemnation of buildings and other structures where they constitute a serious obstruction to view.

Provide Wide Shoulders or Parking Spaces

I have omitted to mention various other safety considerations because they are either obvious or have been already accepted by up-to-date designers; items such as minimum crown; easy grades especially when combined with curves; liberal curve radii; and the provision and maintenance of adequate shoulders. Highway signs are very important for safety but this forms a subject in itself. The same may be said of the elimination of railroad-highway grade crossings, and their protection, and designers have likewise become alert to the need for special provision at the intersections of two important highways. We have come to recognize that the parking of vehicles on the highway is dangerous as well as a nuisance to other motorists and that this can be prohibited only if we provide parking places not more than 300 ft. apart, outside of the pavement line, or better still, a continuous shoulder wide enough for the same purpose. We also recognize today the importance of proper selection and conditioning of detours, for both safety and comfort. The initiative of the manufacturers of new types of metal guard rails has brought rapid progress in this field—for while the slow processes of safety education are striving to make railings unnecessary, the highway designer, facing a condition and not a theory, must still share the responsibility commonly attributed to Providence for watching over drunken men and other fools.

The super-highway—that dream of the highway engineer, in which capacity, safety and speed shall all be at a maximum—is coming every year a little closer to reality. I have not time nor is there need to describe the progress already made in building portions of super-highways near Detroit. The ideal, of course, is a roadway or set of roadways of ample width, proper surface, and each of them carrying homogeneous traffic in one direction only, with no pedestrians and no grade crossings of any sort. In a few highly congested districts it will be economically possible to build such arteries of transportation.

But ninety-nine and a fraction per cent of our highways will always be in the other class requiring a continual balancing of safety versus speed versus cost. Here the "Safety men" ask nothing more than that the highway designer accept safety as one of the objects—not the sole object—of his design, and I for one have nothing but praise for what the highway engineers of today are doing to make our highways safer, with the limited funds at their disposal. The real safety problem on our highways is not poor design but incompetent and careless driving.

DEVELOPMENT OF IMPROVED HIGHWAYS

By Thomas H. MacDonald, Chief of Bureau, and H. B. Fairbank, Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

(A paper read before the Western Society of Engineers, April, 21, 1926.)

Of the 3,002,916 miles of highways of all classes in the United States, approximately 448,000 miles were improved with some form of surfacing at the close of the year 1924, according to the best available estimates. If the last year's work has been as productive as that of 1924—and there is every reason to believe that it has been—the surfaced roads at present aggregate not far from 500,000 miles, about one-sixth of the total mileage.

Accepting the latter figure as reasonably representative of the present condition, it will be convenient hereafter to deal with the more exact figures of 1924, especially since surveys made by the Office of Public Roads in 1904 and 1914 furnish the statistical basis for the determination of the character and extent of the progress made during the last two decades.

According to these surveys there were 257,291 miles of surfaced roads in 1914, and 153,662 miles in 1904. The net increase during the first of the two decades was, therefore, a little over 100,000 miles, or approximately 10,000 miles a year; and this rate was more than doubled during the second and last decade.

The relative progress made during these two 10-year periods, however, is not expressed fully by the net increase in surfaced mileage. It is safe to say that practically all of the roads that were surfaced in 1904 have since been resurfaced and undoubtedly a considerable percentage of the 257,291 miles surfaced in 1914 has also been replaced with new, better and wider surfaces since that date. The real measure of the progress made during the last decade is, therefore, not the net increase of more than 211,000 miles but a figure which much more nearly approaches the total of improved mileage at the close of the period.

Rapid Progress in Last Decade

The true extent of the change becomes apparent when we examine the character of the roads classified as surfaced at the three survey periods. Of the 153,662 miles surfaced in 1904 only 141 miles, or less than one-tenth of one per cent of the total, were improved with a surface better than waterbound macadam. By 1914 the mileage of this class of roads had increased to 14,830, or 5.8 per cent of the total mileage then surfaced; but more than two-thirds of the roads so classed were surfaced with bituminous macadam and surface-treated waterbound macadam, the least durable of the types included in the class. The increase in the mileage of high types to a total of 89,771 miles between 1914 and 1924 is, therefore, more remarkable in view of the fact that the surface-treated and bituminous macadam roads constituted in the latter year less than half of the total mileage of the class, which as a whole represented more than 19 per cent of the total surfaced mileage. More than 45,000 miles in 1924 were paved with concrete, brick, bituminous concrete or equivalent types; and the average width and strength of all surfaces included in the high-type class were doubtless considerably greater than in the earlier years.

In 1904 there were 38,622 miles of waterbound macadam roads—practically 25 per cent of the total surfaced mileage. By 1914 the mileage of this type had increased to 64,898, but the percentage of the total mileage remained practically unchanged at 25 per cent; and in the last decade both the mileage and the percentage diminished, the former to 60,235 miles and the latter to 12.9 per cent, a relative decrease of nearly 50 per cent.

In all three years the roads surfaced with gravel and other low types of surfaces constituted the bulk of the surfaced mileage, but whereas in 1904 they constituted practically three-quarters of the total, in 1924 they represented only a little more than two-thirds. The mileage of these types in 1904 was 114,899; in 1914 it was 177,563; and in 1924 there were 317,960 miles.

These changes in the character of the surface mileage during the two decades are shown more clearly in the table given at the bottom of this page.

Low-Type Roads Served Early Traffic

The year 1904 marks the end of a period. Up to that time there had been no important change in the methods of road construction which had been employed for a century or more. The major types of surfacing were gravel and macadam, and either was known to give entire satisfaction under the traffic normal to the country roads of the time. Other types had been developed and used in small mileage, such as the shell roads of the tidewater States and the sand-clay roads of the South, but the element of availability was the determining factor in the choice of such materials rather than any difference in the demands of traffic; and the same element in fact, largely determined the choice of the two major types.

Thus we find that there was a preponderance of gravel roads in Michigan, Indiana, Illinois, Iowa, Wisconsin, Minnesota and the Dakotas where gravel deposits were plentiful; and a preference for stone in Kentucky, West Virginia and others where suitable gravels were scarce. From New Jersey south, the Atlantic and Gulf States had built rather considerable mileages of oyster shell roads; and the Southern States, in which there was a scarcity of other materials, had developed the sand-clay type. Even the small mileage of high-type surfaces which had been constructed was doubtless attributable less to traffic demands than to the availibility of the materials, for of the total of 141 miles we find that

Class of Surface	1904		1914		1924	
	Miles	Percent	Miles	Percent	Miles	Percent
Gravel and other low types	114,899	74.7	177,563	69.1	317,960	67.9
Water-bound macadam	38,622	25.2	64,898	25.1	60,235	12.9
Surfaces better than water-bound macadam	141	0.1	14,830	5.8	89,711	19.2
Total	153,662	100.0	257,291	100.0	467,906	100.0

123 were paved with brick, and 104 were in the two States of Ohio and West Virginia where brick was cheap and perhaps the most available local material.

Viewed broadly the few types of surface constructed up to this time may all be considered as of one class. In the construction of all the same principles governed; in all a fragmental mass was bound together more or less firmly by a natural cement in the manner made familiar by a century of practice, and all alike depended for their efficacy upon the conic principle of pressure transmission by which they spread the vehicular loads and thus reduced the intensity of pressure borne, by the subgrade .

That need was felt for no other kind of construction was due, of course, to the fact that the traffic on all roads was much the same. Even in the most populous States the greater part of the traffic using the roads consisted of relatively light horse-drawn, steel-tired vehicles, to which were added near the cities a bicycle traffic which, though it might attain considerable volume, was never more than a negligible factor in determining the type of surface. This was the normal traffic condition which existed practically up to 1904. What makes that year a turning point in highway history is the fact that about that time there began the great outpouring of motor vehicles from the cities which quickly set the intercity roads apart from others as a class requiring different treatment.

Motor Traffic Destroyed Low-Type Surfaces

The peculiar effect of the automobile on waterbound macadam roads is so well known as to require no description and the manner in which the road builders met the challenge by substituting tars and asphalts for the weaker mineral binders has been an oft-told tale. First as dust layers then as protective surface coatings, then as binders introduced into roads of the macadam type by penetration, and finally as hot admixtures according to the bituminous concrete principles, these materials, borrowed from the stock in trade of the city street builder, solved the automobile problem in a manner which was apparently entirely satisfactory.

The effect of this development in the road building art is shown by comparison of the statistics of 1904 and 1914, the dates which, to all intents and purposes, mark the beginning and crest of the wave of bituminous construction. In 1904, according to the records, there were in the entire country only 18 miles of bituminous rural roads, all in the two States of Massachusetts and Ohio. By 1914 there were 10,500 miles, a mileage which was nearly three-quarters of the aggregate length of all roads of higher type than macadam. This was the highwater mark of the lower forms of the bituminous types. That it by no means marked the end of their usefulness is indicated by the fact that 3,367 miles of the surface-treated and penetration types were built in 1924. The recession of the tide is indicated, however, by the fact that the mileage of the two types existing in 1924 was less than 50 per cent of the mileage of all types better than waterbound macadam in comparison with the 75 per cent level reached in 1914.

Heavy Loads Require Rigid Slab

It is generally recognized that these two types which came into use with the development of passenger automobile traffic are especially adapted to that class of traffic. The relative decline in their use began when motor trucks in considerable numbers began to appear on the rural highways; and coincidentally we find an increasing swing toward the rigid pavements of concrete and brick and bituminous concrete on a concrete base. The turning point was reached in 1914 or perhaps a year or two earlier.

The first concrete pavement was built at Bellefontaine, Ohio, in 1893, but up to 1909 no more than 5 miles had been constructed on rural highways in the entire country. In that year approximately 4 miles were built; in 1910 about 20 miles were added, the following year 40 miles, and then the first big increase occurred in 1912 when more than 250 miles of rural highways were paved, to be followed in 1913 with 500 and in 1914 with more than 1,500 miles. At the close of the latter year there were in the entire country 2,348 miles; and 10 years later the mileage had increased to 31,146 and construction was proceeding at the rate of more than 6,000 miles a year, a rate approached by no other type better than gravel.

The more extensive use of brick and the bituminous pavements of the mixed type on concrete base began also at about the same time and was due to the same cause—the increased use of motor trucks. In 1914 there were approximately 1,600 miles of brick pavement; in 1924 there were 4,319. In 1914 the mileage of rural highways paved with bituminous concrete or sheet asphalt was still negligible; in

1924 there were more than 9,700 miles of these types.

New Types Developed

The first of the two decades we have had under consideration was marked not only by the development of new types of road, but also by two other changes of even greater significance. The first of these was a general increase in the radius of travel by highway occasioned by the use of the automobile; and the second—a natural result of the first—was a change in the character of the public demand for highway improvement.

In 1904 the automobile had still to prove its ability for sustained performance. Its ownership was still limited to a small and wealthy class. The popular demand for improved roads was, therefore, still predicated upon the use of the bicycle and the horse-drawn vehicle. The farmers, always conservative, were still, for the most part, either actively hostile to road improvement or lukewarm in support of it. In general their demand was for the improvement of the roads connecting their farms with the railroad shipping points or nearby towns. More positive influence was exerted by city and town merchants who sought by road improvement to extend the trading radius and business of their towns and by the limited but influential class of motorists who longed for smoother, mud-and-dust-free roads upon which to operate their vehicles. All these influences combined at first to produce a demand for short stretches of improved roads radiating from the towns and rail shipping points. Later, as the automobile was perfected and its users became more numerous, the latter created a demand for longer, unbroken stretches of improved roads, forming a network connecting the larger towns, a claim that was resisted by the farmers who continued to favor the so-called farm-to-market type of improvement.

State Systems Created

In the smaller Eastern States the conflict never became acute, largely because the distance between towns and market points was so short that the farm-to-market plan of improvement when carried to its ultimate development became practically identical with the inter-town or trunk line plan. Thus we find the issue satisfactorily settled in Rhode Island as early as 1902 by the adoption of a definite system of State highways for construction by the State Board of Public Roads. A similar proposal by the highway commissioner of Connecticut, made originally in 1906, was enacted into a law by State legislature in 1913; and in the meantime Maryland has settled the question definitely by the adoption of an inter-county seat trunk-line system to be improved and maintained in its entirety with State funds under the State Roads Commission. Maryland's system was designated in 1908 and was the first to be placed completely under State control for both construction and maintenance.

That the controversy was not so quickly settled in many of the other States was due mainly to two reasons. First, the important lines of travel in a number of States were not sharply defined. This resulted in some from sparsity of settlement, and in others from the contrary condition of close settlement, with numerous centers of more or less uniform size and importance. States such as Texas and Wyoming were typical of the first group. In them the long distances between centers and the condition of the roads delayed the development of highway traffic between the towns and promoted a use of the highways largely as feeders to the rail lines; and the same remoteness of the towns one from another prevented the early harmonizing of the two plans of development as in the smaller Eastern States by the evolution of one into the other. Of the second class there were such States as Iowa, Kansas and Wisconsin, in which the very number and uniform size of the town centers caused a diffusion of traffic over many roads and delayed the recognition of routes of outstanding importance. In these States also the towns are essentially agricultural centers and this fact contributed further strength to the demand for farm-to-market roads as opposed to trunk lines.

The instances mentioned furnish examples of one of the reasons for the prolongation of the controversy which raged over the question of farm-to-market vs. trunk-line development. The second reason was simply that many of these States as yet had no State agency for the administration of a highway plan of Statewide scope, and the development of the trunk-line plan naturally presupposes the existence of such an agency.

Federal Aid Develops Trunk Lines

The second of these reasons was promptly removed after the passage of the Federal Aid road act in 1916 by the provision of that act requiring the creation of adequate highway departments in all States as a condition precedent to par-

ticipation in the benefits of the Federal aid. And a first step toward the ultimate settlement of the trunk-line question in all States was made when the Bureau of Public Roads as one of its first administrative acts requested of all States the submission of a 5-year program map showing the system of roads upon which the State highway departments would request Federal aid during the period covered by the appropriations provided by the first act of Congress. Although the systems designated in response to this request were understood to be merely tentative the request of the Bureau had the effect of directing attention—in many States for the first time—to the desirability of establishing a definite program for the improvement of a system of highways as distinguished from the more or less casual improvement of unrelated sections of roads.

The Federal aid work had scarcely begun, however, when the war intervened and practically put a stop to all operations; and the war did a number of other things to the existing improved roads which, however disastrous they may have appeared at the time, have turned out to be blessings in disguise. At the outset the construction and maintenance of highways were declared to constitute a nonessential industry. As a consequence new construction, except as required for the immediate service of the army, was greatly curtailed. This result is reflected in the records which show in 1916—the year before America's entrance—a construction of the roads under the supervision of the State highway departments amounting to 16,160 miles; a decline to 11996 and 11,944 miles respectively in 1917 and 1918; and a return to 18,260 miles in 1919. Maintenance also was greatly hampered by the difficulty of obtaining the necessary materials and the scarcity and high wages of labor. At the same time there was released upon roads generally inadequate to stand it an unprecedented traffic of heavy motor trucks. To this experience and the heavy damage which followed we owe the development of most of the sound principles and policies which now govern the improvement of highways.

The first result was a strong reaction against the use of heavy motor trucks. There were large numbers of people who, forgetting that a road is of service only in so far as it accommodates the need for economical transportation, demanded that the manufacture and operation of vehicles too heavy for the existing roads be prohibited. As few of the roads were designed to carry motor truck traffic, to have taken this course would have amounted to the throttling of a new development in transportation before it had a chance to demonstrate its utility, and it was rightly opposed with great energy by the manufacturers of motor vehicles. The latter, on the other hand, took a position at the opposite extreme from which they demanded the right to manufacture and sell heavy vehicles of large capacity, without regard to the strength of the roads, on the theory that the greater the capacity of the vehicle the smaller would be the cost of operation per unit of capacity. Their slogan was "build the roads to carry loads," and this was met by the opposite party with the equally dogmatic demand that the loads should be limited to the capacity of the existing roads.

The issue thus joined, the principals to the controversy, highway officials on the one side and the manufacturers on the other wisely agreed to submit their difference to the test of mutual discussion; and out of the series of conferences which ensued there came an agreement upon certain fundamental facts and principles which have served as the basis for a harmonious co-operation of the two groups, and which now constitute the foundations of highway improvement policy in all States.

Agree on Maximum Loads

It was agreed at the outset that for the first time in history the weight of vehicles had become a critical factor in rural hihgway design. Hitherto the minimum practical thickness of road metal had been sufficient to carry the maximum vehicular load. The development of the motor truck had altered this situation. It called for stronger surfaces that would spread its heavier load over a wider area of the subgrade in order to reduce the intensity of the pressure to an amount which the soil would support.

It was clear also that whereas deterioration of the highways had previously resulted mainly from the attrition of the surface, a new form of deterioration approaching rapid destruction would result unless the roads upon which the heavier motor trucks were being operated were strengthened so as to enable them to carry the increased weights. And whereas, the amount of the deterioration had formerly been a function of the volume of the traffic and of time, the new destruc-

tion by excessive weight might be caused by a few vehicles in a very short time.

It was agreed, therefore, that the highway officials must have definite knowledge of the maximum weight to be supported as a first condition of design; and this knowledge was supplied, in a measure, by the voluntary decision of the manufacturers to limit to 7½ tons capacity the future production of vehicles. Engineers were thus assured that if, in the reconstruction of the thoroughfares upon which heavy trucking had developed, they would design to accommodate a vehicle of 7½ tons capacity they would not see their handiwork quickly destroyed by vehicles of much greater size and weight.

Reduce Total Cost of Transportation

But this alone was not a sufficient basis for the design of all roads. The building of roads of sufficient strength to carry 7½-ton trucks required a heavy investment of public funds, which could be justified only if the economies inherent in the transportation of goods in vehicles of large capacity were sufficient to outweigh the increased cost of the roads. It was recognized clearly for the first time that the cost of highway transportation is made up of the cost of the highways and the cost of operating the vehicles over the highways, and it was agreed that the common purpose of the public highway officials, vehicle manufacturers and operators should be to reduce the total cost of transportation rather than one or the other of the elemental costs. It could be proved that the number of large-capacity trucks already using some of the highways—principally those radiating from and connecting the larger cities—had already grown to the point where the combined savings in operating cost would more than balance the greater cost of providing highway service for them. As to these highways there could be little doubt of the wisdom and economy of building a type of surface adequate for the heavy truck traffic. Other roads, similarly located with respect to cities, had not yet developed a sufficient amount of heavy traffic to repay the additional cost of the stronger construction, but it was not difficult to foresee that such a condition would develop in the future. On the majority of the roads, however, the development of traffic of sufficient weight to justify the higher types of construction was very remote; and it was apparent that the one-time prevailing condition of uniformity of traffic of all roads had been definitely broken down. Instead, a new and much different condition had arisen under which the main inter-city roads were found to be carrying traffic far in excess of the much greater mileage of local roads.

Under the new condition the economic justification for the improvement of the main roads lay to a far greater extent than formerly in the reduction of transportation costs and to a lesser degree in the effect upon the value of property. The main roads had become through traffic arteries, as distinguished from the more numerous local roads which continued to be of value primarily through the service they render in giving access to the land.

Main Road Traffic Increases

As to the main roads, which carried a wide-ranging traffic, it was now clearly apparent that the character of their improvement must be commensurate with the density of their traffic; that continuity of improvement was of the highest importance; and that the traffic was already so great that the loss in operation of vehicles in the absence of road improvement would exceed the cost of improvement. These roads also were distinguished in one other respect, namely, that their traffic tended to increase far more rapidly than that which was to be found on the local roads, the condition of which remained much as it had been. Where the main roads carried long-distance traffic, the local roads served the traffic of a neighborhood; where the main roads were collectors of traffic, the local roads were feeders and distributors; where the traffic of the main roads tended to grow in direct proportions to the growing use of motor vehicles and the growing resort of industry and the entire people to highway transportation, the local roads served the much lighter, and, from the standpoint of growth, far more stable traffic produced by a single agricultural community.

It became apparent, therefore, that the economic justification of local road improvement would continue to rest largely in the value and importance of the land that, in the main, the traffic would demand only a low type of improvement; and that continuity of the improvement was not so essential as in the case of the main, through roads.

National System Established

The need of continuity in the improvement of the main roads was the first of the new conditions to be met with ap-

propriate action. From 1915 on, all States in rapid succession designated systems of State roads, including generally the main inter-city roads, to be improved under the more or less direct supervision of the State highway departments; and the several State systems were substantially welded into a national network by the designation, in 1921 of the Federal aid highway system which, though not quite co-extensive with the State systems is practically co-incident with them throughout its extent.

Continuity of improvement of the main roads thus assured it remained for a joint committee representing the American Association of State Highway Officials and the National Automobile Chamber of Commerce to enunciate a policy with respect to the rate and manner of the improvement which could win general support and adoption.

Briefly that policy may be stated as follows. It is accepted as a truism that the volume of traffic on the main roads is so great that the economies in transportation effected by road improvement clearly outweighs the cost of the improvement. This being true the improvement should proceed as rapidly as available supplies of labor and material will permit and without other limit. All roads should be improved to the degree justified by the operating savings that may be expected to accrue to the traffic, and no road should be improved to any greater degree. Where the mileage of road to be improved is so great that the type of improvement indicated by the traffic cannot be completed on the whole mileage within a short period the most important sections should be raised immediately to ultimate type, and the balance of the mileage should be advanced through the initial stages of grading, draining and low type surfacing in order to spread as much of the benefit of improvement as quickly as possible over the entire road system, further improvement to await the completion of the first stage over the whole system. This is the practice known as stage-construction and it is the only feasible practice in the numerous states in which a large mileage of main roads remains to be improved in the face of a traffic already highly developed. It is also the logical plan of dvelopment for the main roads of the states in which traffic has not yet grown to the proportions justifying high-type surfacing.

Plan for Ultimate Growth

In any case the stage-construction plan takes account of the rapid growth of traffic, which is a characteristic especially of the main roads, by providing fully in the initial stage for the subsequent construction. Grades and alignment are designed to meet ultimate requirements; drainage structures are built of durable materials; rights-of-way of ample width for the future are obtained; and the initial surfacing becomes the sub-base of the second-stage surfacing. Obviously the soundness of the plan is contingent upon the complete and continuous maintenance of each stage of the construction, a kind of maintenance which—thanks to the war experience and the standard established by the Federal Highway Act—practically all states are now prepared to give.

The accepted policy contemplates the improvement of the main roads, to which the above methods are applicable, as a responsibility of the states to be assumed through the agency of the state highway departments, and financed, in large measure, by the revenues derived from the taxation of vehicles and motor fuel. The local roads are viewed as the responsibility of the counties and lesser subdivisions. With a few important exceptions, as in the case of Cook County, Illinois, and the vicinity of other large cities, the degree of improvement required does not rise above the lower types of surfacing, the expense of which may be met as it should be, by taxation of the local land and property.

These, then, are the outstanding developments in highway improvement of the post-war period: The classification of highways according to traffic density; the designation of state highway systems in all states, the systems including the heavy traffic highways of state-wide importance; the inter-section of the state systems by means of the Federal-aid system; the improvement of roads in accordance with traffic demands to the limit set by probable operating savings; the stage-construction plan of progressive improvement of entire systems; and the development of adequate maintenance provisions. In the main, all are outgrowths of the war experience fostered by Federal aid.

Research Develops New Science

One other great advance has characterized this period—the application of scientific research to the problem of developing types of construction and methods of administration and finance adequate to meet the demands of the fast-

growing traffic. In this also the initial impulse came from the Federal government and, in co-operation with state highway departments and universities, it is continuing to support numerous studies in several fields, as a result of which there is being built up gradually the structure of a new science—the science of highway engineering.

The investigations include studies of the characteristics of materials—sand, stone, gravel, bituminous materials, cement, concrete and brick; determination of the forces applied to road surfaces by standing and moving vehicles; of stresses developed in the structure of roads and bridges by live loads, and by temperature and other natural causes; analyses of subgrade soils and tests of methods designed for their improvement; studies of the flow of water through drainage structures, of the run-off from drainage areas, of the effect of moisture on soils, and many others of fundamental importance and value.

Popular interest has centered upon the large scale tests such as those of the Bates Road, for which entire credit is due the Illinois department, the Pittsburg (Calif.) experiments, the impact tests at Arlington, Va., and the intensive studies of highway traffic conducted by the Bureau of Public Roads in co-operation with the authorities of Connecticut, Maine, Pennsylvania, Ohio, California, Tennessee and Cook County, Illinois.

Building for the Future

Much that is of immediate practical benefit has already been derived from these investigations; but, for the most part, they are dedicated to the future.

It is not to be expected that their fullest benefits shall be immediately realized. The building of a science is a laborious, a painstaking process, and we are still but laying the groundwork which is not much further advanced than were the foundations of the modern science of medicine and surgery 50 years ago. If 50 years hence the science of highway engineering has been built up to the point now attained by the physicians and surgeons this effort we are now putting forth will be abundantly repaid, and not too late. For the improvement of highways in the United States is a process which must be continued indefinitely.

It is idle to talk of completion when of the three million miles of our highways less than a fourth have been graded, but a sixth has been surfaced and a sixtieth paved; when little more than half the mileage of the main state roads has been improved with any kind of surfacing, and there remain on these important arteries thousands of substantial one-way bridges and dangerous railroad grade crossings; when the number of motor vehicles registered is doubling every fifth year and the traffic with them; when the size of our cities and the magnitude of our industries, and the amount of our material wealth are increasing at an almost unprecedented rate. So long as these conditions continue we shall continue to build and maintain and rebuild our roads.

At the present rate we are surfacing approximately 40,000 miles a year and our annual expenditure approximates a billion dollars. There is no indication of an early reduction in these rates of construction or expenditure, dwarfed as they are by the annual production of a 1,000,-mile procession of motor vehicles and an annual expenditure for operation approaching ten billions. As a nation we have set our hand to the economic improvement of our means of highway transportation. It is not a task to be accomplished in a day. It is, and must be a continuous process. There is but one limit which may reasonably be set. It is this: No road should be improved by expenditures of public funds in excess of its earning capacity. The return to the public in the form of economic transportation is the sole measure and justification of the degree of highway improvement.

THE PRACTICAL WORKINGS OF THE INDIANA TAX PLAN

By Philip Zoercher, Member Indiana State Board of Tax Commissioners, State House, Indianapolis, Ind.

(From an address at 1926 Conference of State Board of Tax Commissioners and County Assessors of Indiana.)

The statute of our State provide that there shall be an annual conference of county assessors called by the State Board of Tax Commissioners at a time and place to be determined by the board and pursuant to the order of this board you have appeared this morning. The object of the meeting is to consider matters that will aid in bringing about a more equitable assessment of property in the state. It has been my contention in the past that the great difficulty confronting the officer is the general ignorance on the question of taxation. How can this be overcome? There ought to be more public meetings to consider the question of

taxation. There are still a great many people who believe that valuations make the taxes instead of the budgets and the amount of money spent, and in every community the local taxes are the highest and form the heaviest burden on the taxpayer. Indiana is more fortunate than other states as will be shown.

What Are Taxes?

Judge Cooley has said: "Taxes are the enforced proportional contribution from persons and property, levied by the state, by virtue of its sovereignty, for the support of government and for all public needs." And Judge McCabe, of the Indiana Supreme Court, as shown in the case of State v. Express Co., 144 Ind., 560, said:

"It is but natural that the tax gatherer should be made an unwelcome visitor by many good people. But the good citizen should take comfort in the payment of his taxes when reminded that it is such payment that enables the majesty of the law to walk by his side and shield and protect him against the lawless and violent both day and night in the enjoyment of life, liberty and prosperity."

The fact that all should be taxed is not even new. In Holy Writ we find this statement:

"And it came to pass in those days that there went out a decree from Caesar Augustus that all the wold should be taxed." Luke II:1.

Decrees of similar import are made by public officials today. Let us consider Indiana's system.

Does Government Pay?

What do the various taxing units give in return for the taxes exacted from their citizens. When the taxpayer begins to enumerate the returns he will find that great service is given in return for the taxes paid. With our system of controlling expenditures, taxes should be kept within proper bounds and the taxpayers given value received for money paid; if this is not done, it is because the taxpayers have not exercised their rights of appeal on bond issues and tax levies.

Taxes Collected on Property Valuation

Under our constitution "The General Assembly shall provide for a uniform and equal rate of assessment and taxation; and shall prescribe such regulations as shall secure a just valuation for taxation of all property both real and personal except such only for municipal, educational, literary, scientific, religious, or charitable purposes as may be especially exempted by law." Every session of the legislature adds to the list of exemptions and some do not seem to come within the exceptions set out in the constitution. In order that the burden of government be properly distributed it becomes necessary that all property should be placed on the duplicate. This is the work of the assessing officers. The State Board in 1918 in its report to the legislature of 1919 submitted a plan which provided for a method that I believe would have greatly increased the assessment of intangible property, and until some method of that kind is adopted by the General Assembly it will always be a problem that will be difficult to solve.

Importance of Office of Assessor

At the last session of the National Tax Conference held at New Orleans, La., last November a paper was read by a member of the State Board of Mississippi. It was clearly shown that the office of assessor is one of the most important of all public offices. After going into the duties of the assessor it was shown by the speaker that many are elected to the office that are not qualified to fill the office and on account of the failure to properly function he advocated that assessors be appointed and not elected. Similar reports and recommendations have been made in this state but we still have this as an elective office. During the year 1926 there will be elected county and township assessors in the state of Indiana. Those officers who have done their duty and are candidates for re-election ought to be re-elected. Of course, that is the business of the voters and is to be determined first at the primary and later at the election, but no man ought to enter the race for township or county assessor who is not willing if elected to do his duty as the law requires.

Work of the Assessor

There is no more important work in connection with the public than that of the assessor. His work if correctly done forms the basis upon which the taxes are levied and will be equitably distributed and each taxpayer will contribute his proper share. If the work is not properly done, and there is an uneven and improper assessment then some taxpayers are bearing more than their share of the public burdens. The taxpayers as a general rule pay little attention to their rights and many times wait until it is too late to make corrections. Very often assessors assess persons and not property. How officers can justify unequal assessments is difficult to understand. While

we can not reach the ideal it is possible to improve the standard of equity in every county each succeeding year. The township assessor, or his deputy, is to call on every citizen and personally administer the oath to every personal return. On this blank are three columns, one for the taxpayer, one for the township assessor, and one for the county assessor. The township assessor should not hesitate to use his column if he is of the opinion that the taxpayer has not given the proper valuation on his property. The assessor is not a mere list taker; he is an assessor and it is his duty to see that proper valuations are made. After his work is completed and he makes his return he attaches an oath that he has in every instance and by the best means in his power, endeavored to ascertain the true amount and value of such personal property and assessables and that the full value thereof is set forth in the return.

The County Assessor

It is the duty of the county assessor to examine the returns made by the township assessor and report to the board of review for the action of the board all corrections and changes in the returns and assessments of the township assessor. The county assessor is authorized and required to advise and instruct all township assessors of his county as to their duties under the law. It is also made his duty to report to the State Board of Tax Commissioners the incompetency or neglect of duty on the part of any township assessor or deputy assessor in order that the State Board may take action for the removal of such assessor or deputy assessor.

The Board of Review

Is composed of the county assessor as chairman, the county auditor as secretary, the county treasurer and two freeholders of opposite political parties to be appointed by the judge of the circuit court. It is the duty of this board to review all the assessments made, pass on the recommendations of the county assessor, pass on all mortgage deductions and make such changes as are necessary to secure a proper valuation of property within the county. No increase shall be made by the board of review of individual taxpayers assessments unless notice is given the taxpayer that he may appear and be heard on such increase. Notice of such proposed increase shall be given at least three days before the matter comes up for hearing. The board of review may, if necessary, for the purpose of equalization determine a per cent of addition or reduction for any class or classes of property within the respective townships or divisions of townships or any taxing unit. No notice of such action is necessary; the notice given the taxpayer of the meeting of the board of reviews is all the notice required to be given in such cases.

The Taxpayer's Rights

Any taxpayer who may not be satisfied with the assessment placed against him for personal property or real estate shall appear before the county board of review during the month of June and if he is not satisfied with the action of the county board of review he can within five days of the adjournment of that board file with the county auditor on blanks furnished by the auditor an appeal to the State Board of Tax Commissioners asking that board to pass on such appeal. The taxpayer may also upon a verified application duly filed with the State Board at any time prior to the first Monday in November of the year following the assessment ask for a review of the assessment if the taxpayer has been wrongfully charged with taxes. It should be remembered, however, that no taxes shall be considered as having been wrongfully paid or as having been wrongfully assessed when same were extended on assessments made as the judgment of taxing officers authorized to make same and concerning which no complaints were registered at the time same were made either by application for rehearing or by an appeal.

The State Board's Powers and Duties

The State Board of Tax Commissioners has four sessions for assessment purposes. The first session which convenes the first Monday of April and continues for fifty days is the session during which the State Board considers and fixes the assessments on all steam and electric railroads, telegraph and telephone companies, all public utilities, transportation companies, pipe lines, banks and trust companies and all building and loan companies. During the second session which convenes the Tuesday after the first Monday in July and continues in session for twelve days, the board considers appeals and rehearings on assessments fixed at the first session and during the first five days determines the counties in which it appears that the property is improperly assessed and fixes a day or days in the third session when it will consider the matter of the modification of such assesments.

The State Board shall convene its third session the third Monday in July and remain in session until the third Monday in August except that the third session may be extended for ten days for equalization purposes only. During the third session it shall be the duty of the State Board after having examined the abstracts and having made investigation and after having had hearings, to make such equalization orders as appear necessary to bring about a proper valuation within the county and as between counties. Whenever changes are considered necessary to be made notice shall be given the county auditor who shall reconvene the county board of review on Tuesday after the first Monday in August to consider such certified report and all the information therewith. At such special meeting the county board of review shall have power and it shall be its duty to make and issue such further orders of equalization as it may find just and proper. Said special meeting shall not extend beyond five days and immediately upon the adjournment thereof, and not later than the second Monday in August the county auditor shall certify to the State Board such further orders of equalization as the county board of review may have made. The State Board in its final orders shall consider the classes of property as set out in Section 192 of the tax law as affecting the entire county. During the third session the State Board shall hear appeals and determine the cases for certification for review and reassessment. This latter must be determined not later than the third Monday in August.

At its fourth session which convenes the third Monday in September and remains in session until the Saturday following the first Monday in December the board shall determine tax levies in those tax units in which ten or more taxpayers may have filed their petition with the county auditor asking for such review by the State Board.

Assessments certified at the third session may be determined at the fourth session. Appeals not heard at the third session may be heard at the fourth session.

Justice for All

Here is enough administrative machinery to secure a correct assessment of all property if the taxpayers and the officers will work in harmony to secure such valuation. If as a result of equalization orders property is increased beyond its true cash value and information thereof given to the State Board such property may be certified for review and reassessment provided such information be given the State Board by the third Monday in August. This time ought to be extended to a later date and a recommendation asking such change was made by the State Board to the last two sessions of the legislature, but the change has not been made.

What Increases Taxes

Last spring it was my duty to talk to the assessor in one of the southern Indiana cities. A survey showed that real estate in that city was greatly undervalued and the assessors were urged to do their duty and make a proper assessment. In addition to the assessors there were some real estate owners present and one of the latter openly opposed assessing property as the law requires and said that an increased assessment would mean higher taxes. It was explained that the budget of the local taxing units would determine whether there would be an increase in the taxes. As a result of the work of the assessors there was quite an increase in the valuation of the property in that community. At the proper time, i. e., before the fourth Monday in September, ten or more taxpayers filed a petition with the county clerk and asked that the budget and tax levies of the taxing units of that county and community be reviewed. At that meeting the taxpayer who so vociferously objected to a proper assessment was not present and did not object to increased expenditures proposed in local budgets. It is the amount that is spent and not the valuation that determines the taxes.

President Coolidge

In his inaugural address the President among other things said:

"I favor the policy of economy, not because I wish to save money but because I wish to save people. The men and women of this country who toil are the ones who bear the cost of Government. Every dollar that we carelessly waste means that their life will be so much the more meager. Every dollar that we prudently save means that their life will be so much the more abundant. Economy is idealism in its most practical form. * * * The wisest and soundest method of solving our tax problem is through economy."

Cost of Government

The cost of government is high in some instances because of the extravagance of public officials or because the people

themselves demand luxuries. It has become the habit of many public officials to take up every new fad or fancy and seek new avenues for the spending of public money. In ordinary life every citizen is taught to live within his income and the most successful business man is he who secures full return for every dollar that is spent.

What Is the Remedy?

We were often subject to the whims and caprices of public officers and had to submit to the spending of money foolishly and unnecessarily. We do not have the recall in Indiana. Some of our officers are elected for two years, others for three years and still others for four years. The editor of the National Municipal Review suggested that giving the right to local taxpayers to appeal tax levies and budgets to the State Board of Tax Commissioners was violating a principle of home rule and suggested that when the next election comes on the officers guilty of squandering public funds could be defeated at the polls. How could that help the taxpayers from being compelled to pay the bill for the squandered money? The Indiana plan offers a remedy whereby a wide-awake citizenship can stop the unnecessary spending of public funds.

Limitation of Expenditures

For many years prior to 1919 the reports of the State Board of Tax Commissioners showed an utter lack of uniformity in the assessment of property and year after year the burden of taxation was being increased on real estate. The commission that prepared the bill which resulted in the law of 1919 realized that if proper assessments were made some limitation or restriction on tax levies and bond issues would be necessary to avoid a large increase in taxes.

Governor Marshall's Recommendation

The late Thos. R. Marshall in his last message as Governor of Indiana in 1913 said:

"I recommend further that no bonds shall be issued until application made to the State Board of Tax Commissioners asking for leave to issue the bonds and showing the purpose of the issue is granted; and that board grant no leave until it has fixed the minimum price at which the bonds may be sold."

This suggestion was incorporated in the idea of bond control in the law of 1919.

First Assessment Under Law of 1919

When the first assessment under the new law was completed it showed an increase in valuation from $2,233,761,065 to $5,749,258,800 which increased the borrowing power of every taxing unit on an average of two and one-half times. The law provided that as the valuation increased the fixed tax rates should automatically be reduced and before the officials of any municipality could increase levies for all purposes in excess of $1.50 on each one hundred dollars, they were required to petition the State Tax Board for such authority.

First Year's Reduction

The reduction in levies made by the board during the first year amounted to $11,617,037.

The total taxes in the state for all purposes were increased from $68,367,035 the last year of the old law to $75,602,477 the first year under the new law. Part of this increase was due to a new levy for state highway purposes.

The denial of bond issues and the cutting out of $11,617,037 caused an agitation of the money spenders against the powers granted the board. A special session of the legislature was convened in July, 1920, and the power over bond issues and tax levies was taken away and power granted the county council to review bonds and tax levies on petition of fifty or more taxpayers.

Cost of Home Rule

The tax levies of 1920 were fixed by local officers with the check removed and taxes were increased in one year $36,000,000. This cost of "home rule" was so vividly impressed upon the taxpayers that the legislature of 1921 promptly amended the law and gave the State Tax Board authority over bond issues in excess of $5,000 and all tax levies on petition of ten or more taxpayers.

Tax Levy and Budget

Amended Section 200 of the tax law provides that the several tax levies shall be established by the proper legal officers of any municipal corporation after the formulation and publication by them of a budget on forms prescribed by the State Board of Accounts showing in detail the money proposed to be expended during the succeeding year, the valuation of all taxable property within the jurisdiction and the rate of taxation which it is proposed to establish. A public hearing at which any taxpayer shall have a right to be heard is provided for. A ten days' notice of such meeting must be given by publication in two newspapers of opposite political parties. The taxpayer is thus given due notice what amount is asked

and the purpose for which the money is to be used.

The Supreme Court of Idaho in deciding the case of Graves v. Berry, 207 Pac. 718, held that the officers are limited to the amount set out in the budget and for the purposes therein designated. The making of a previous estimate of the necessary or probable expenses of the municipality, and notice to taxpayers of the meeting of the board which is to levy the tax are conditions precedent to the validity of the tax.

Budget Limits Expenditures

Every department of government, when its budget is fixed and the tax levy determined must prepare to do its business within the amounts set up in the budget. The amount thus fixed is the limit beyond which the official cannot go. It is surprising how many departments will serve the public and live within the amounts designated. It will encourage economy on the part of all officials when their slogan is "Live within the budget."

The form of the budget also sets out the amounts spent the three preceding years and balances on hand so that the taxpayers know whether the tax burdens are increasing or decreasing, or if the officers are endeavoring to build up unwarranted large balances.

Experience of Carroll County

In September, 1923, an appeal was taken by taxpayers in Carroll County. When the budget was published it showed that the county officials were asking an increase of four cents in the county levy. When the taxpayers appeared before the county council at the time the levy was fixed they were ignored and no consideration shown them. At the hearing on the appeal before the State Tax Board it was shown that the county had on January 1, 1923, a balance in the general fund of $192,000 with a budget of only $80,000. As a result of the hearing the entire county levy was wiped out for the year. The budget form only calls for a working balance to run the county six months and does not contemplate such large balances as was shown in that case.

In September, 1924, the county council fixed the levy for county purposes for the coming year at four cents on the hundred dollars. Ten or more taxpayers appealed to the State Board to review the levy and at the hearing it was shown that on January 1, 1924, there was a balance in the general fund of $172,585 with a budget of $89,000 for this year. The budget for the coming year is $77,950. By adding receipts other than taxes and poll tax it was shown that on January 1, 1926, there would be a balance in the general fund of that county from $45,000 to $50,000, and again the entire county levy was wiped out.

School City of Indianapolis

Last August the school city of Indianapolis published a budget and a proposed tax levy of $1.36 on each one hundred dollars. The Indiana Taxpayers Association has its headquarters in this city and its executive secretary has been very watchful of bond issues and tax levies. The civil committee of the Chamber of Commerce was also busy and its expert was giving personal attention to aiding in making proper reductions in the budget. The budget was trimmed and the levy was reduced by the School City to $1.10 which was a reduction of $1,695,200.

But for the right of appeal to the tax board no such reduction would have been made.

In Sullivan County

Taxpayers of Sullivan County in September, 1924, filed a petition to review their tax levies. It was shown that the local officers had increased the county levy from thirty cents to forty-one cents and for gravel road repair fund from twenty-five cents to fifty cents on each one hundred dollars. The budget as published called for $152,357 and the forty-one cent levy with the receipts other than taxes was shown to raise $190,000. The levy was reduced and fixed by this Board at thirty-two cents on the one hundred dollars and the gravel road repair levy left at twenty-five cents. That was shown to raise more than the average per mile in the State. This reduction was a saving of $134,810 in that county for the coming year.

In September, 1925, the taxpayers filed a petition to review the county levies. At the hearing it was shown that the officers under the item of $60,000 for repair of bridges was added by the county without giving the location of the bridge or bridges. The law says the officers shall set out in detail and this failure to itemize caused the state board to eliminate that item and the levy was reduced accordingly. Another item of $60,000 for repair of the court house was added by the county council which was included in the published budget. The taxpayers having had no notice of this item it was not approved and no levy provided therefore. The levy in 1925 was reduced twen-

ty-six cents on the hundred dollars which amounted to $85,860.

La Porte County

A similar condition was shown in La-Porte County. The officers in the budget simply gave the total amount and where it said give location, the officers inserted the words "in the county." That was self evident because the county could not build bridges except within the county. At that hearing the spokesman of the taxpayers related an instance where a bridge was built in Hanna Township across a stream where there was no public highway. That occurred before the passage of the new law.

Other Instances

At one of the hearings held last fall local officers had figured on receipts other than taxes at $7,000. The officers were called on to produce the record and it was shown that the amount was really in excess of $35,000. A reduction in the levy was made amounting to $28,000 in taxes.

In another instance a levy of fifty-five cents had been fixed by the local officers for tuition purposes. It was shown that a large balance was being carried over and the attorney of the trustee admitted that the entire levy could be wiped out and still leave a nice balance on hand at the end of the school year. Many other similar instances might be given.

How Hearings Can Be Had

If objection is made to any budget item or to the amount in the budget and the local officers at such hearing do not give proper heed to the demands of the taxpayers, the taxpayers, ten or more, may file a petition with the county auditor on or before the fourth Monday of September, and demand that the budget and tax rate be reviewed by the State Tax Board. A hearing is then held by the State Tax Board in the county where the taxing unit is located and after such hearing it has authority to approve or reduce the tax levy—no increase can be made by the State Tax Board. The Boards' action on such levy is final.

Hearings Are Informal

The hearings are informal. The taxpayers are not required to employ attorneys to represent them at the hearing. There is no objection when attorneys are employed but the idea is that the taxpayers should feel free to take the appeal and not be compelled to incur the burden of paying attorney fees when an honest attempt is made to reduce the tax burdens. All that is required of the taxpayers is that they appear at the hearing and in their own way give the reasons for objecting to the proposed tax levy or bond issue as the case may be.

No costs attach to any of these hearings. The law does not provide for witness fees; hence no costs can be taxed against the taxpayers in taking any of these appeals. The jurisdiction of the State Tax Board is limited to approving or reducing tax levies and to approving, reducing or denying bond issues. In no instance can there be any increase in tax levies or bond issues as a result of any appeal.

Reduction in Levies

In the year 1919, the State Tax Board when it had control over all levies, reduced levies amounting to $11,617,037. In 1921, with authority to review only on petition of ten or more taxpayers, the State Board reviewed tax levies in forty-two taxing units and made reductions in thirty-nine taxing units, the reduction amounting $1,254,448.

In 1922 the tax levies in seventy-four taxing units were reviewed by the Tax Board and reductions made in forty-six taxing units amounting to $1,034,572. In 1923 the tax levies in thirty-seven taxing units were reviewed and reductions were made in twenty-five, amounting to $1,874,-070.

In 1924 the tax levies in forty-eight taxing units were reviewed and reductions were made in forty-one taxing units amounting to $1,467,345.

In 1925 tax levies in one hundred and thirteen taxing units were reviewed and reductions were made in sixty-five amounting to $1,554,004.

The possibility of an appeal to the State Board operates automatically as a restraint on most local taxing officials. The law, therefore, has a corrective influence far beyond the specific cases in which reductions are ordered upon appeal and reviewed by the State Board.

The action of Governor Jackson in making an appeal to all local officers in the state urging them to see that the budgets be reduced to a minimum consistent with public needs did much good to remind officers of their duty and obligation to the taxpayers.

Reviewing Bond Issues

If the remedy would only apply to tax levies the problem would only be partially solved. Amended Section 201 of the Indiana Tax Law refers to bond issues and provides that wherever the proper officers of any municipal corporation contem-

plate the issuing of any bonds or other evidences of indebtedness in amounts in excess of $5,000 two weeks' notice of such determination must be given the taxpayers. Such notice must show what the money is to be used for and the assessed valuation of the municipal corporation and its total indebtedness. The notice also contains the information that ten or more taxpayers, other than those who pay poll tax only, who feel themselves aggrieved by such determination may appeal to the State Board of Tax Commissioners for further action by filing a petition therefor with the county auditor setting out that such contemplated improvement is unnecessary, unwise, or the cost thereof is excessive.

Holding of Supreme Court

Under the law as passed in 1919, all bond issues had to be submitted to the State Tax Board. This power conferred upon the State Board was questioned in the courts. The Supreme Court of Indiana in the case of Van Hess v. Board, 190 Indiana 347 (354), held:

"Questions of the expediency of improving this particular six miles and a half of highway, at an expense of $30,000 per mile, and paying for it out of the taxes to be collected in a certain number of years, instead of using those taxes to improve or to maintain some part of the other hundreds of miles of highways in the county, or to pay for school houses, or bridges, or a courthouse or jail, or something else for public use, and instead of collecting a less amount of taxes, must be decided by somebody. For there is a necessary limit to the amount of taxes that can be collected in any one year, and a limit to the amount of taxes that ought to be levied, even though it might be possible to collect them. And whatever part of such taxes are used to pay for this highway can not be used for other public purposes, nor can the people use for private purposes what they are compelled to pay as taxes. * * *

"Which of the different possible improvements that would be of public utility shall have the preference, or whether any of them shall be undertaken at a given time, are not judicial questions, but are such questions as may be referred to a public board charged with duties in the assessment of property and levy of taxes. The fact that the state board of tax commissioners does not possess judicial powers is not a reason why it could not be empowered to decide that question. Boards having to do with the levying of taxes and the expenditure of money raised by taxation must always exercise a discretion as to the general purpose for which each tax should be levied and the amount to be levied for each of such purposes, and as to the nature and amount of each specific expenditure from any general fund."

This opinion was given concerning the law as passed in 1919 and before the amendment of 1921 was adopted. Since the amendment of 1921 the State Tax Board has nothing to do with any bond issues, except when ten or more taxpayers file their petition asking the State Board to pass on any bond issue. This removes the objection made in 1919 of a centralized board interfering in local matters.

How the State Board Acquires Jurisdiction

It is only when the local taxpayers themselves have some difference as to the wisdom of spending the money proposed by the bond issue and ten or more of the taxpayers file a petition that the State Tax Board acquires jurisdiction.

Judging from its duties and powers, the State Tax Board is a proper board to consider questions of tax levies and bond issues.

The State Board of Tax Commissioners is composed of three commissioners appointed by the governor, each for a term of four years, not more than two of whom shall belong to the same political party. The Board with the advice and consent of the governor has power to employ such counsel, engineers, examiners, experts, clerks, accountants, and other assistants, as it may deem necessary.

Duties of State Board

This Board has original jurisdiction in assessing all railroads, both steam and electric, telegraph and telephone lines, pipe lines, express companies, sleeping car companies, all public utilities, banks and trust companies and building and loan associations. It has charge of the inheritance tax department. It has authority to equalize assessments between counties of the State. It has a right on its own initiative to certify for review and reassessment any assessment in the State. Taxpayers have a right to appeal to this Board from the action of the local board of review. The law requires that the members of the Board devote all their time to the duties of the office.

Bonds approved and disapproved, March 11, 1919, to December 31, 1920:

	Approved	Disapproved
County unit roads	$5,186,750	$2,235,664
County buildings and bridges	5,292,993	807,600
Township roads	21,249,993	2,598,562
Township schools	5,272,776	1,863,553
Civil cities and towns	8,826,715	948,138
School cities and towns	12,741,044	739,500
	$58,569,335	$9,193,617

Bonds approved and disapproved, March 10, 1921, to and including December 31, 1925:

	Approved	Disapproved
County unit roads	$5,261,296	$4,081,629
County buildings and bridges	409,320	183,000
Township roads	5,819,010	8,302,520
Township schools	6,946,554	3,227,413
School cities and towns	6,346,063	1,439,400
Civil cities and towns	2,162,500	1,179,500
	$26,944,743	$18,413,462

The fact that a bond issue may be appealed to the State Board has in itself tended to keep down the prices in many cases.

Lima Road in Allen County

There was one case where it was proposed to issue bonds in the sum of $570,000 for the building of the Lima Road in Allen County. A petition was filed with the county auditor asking that the same be reviewed by the State Tax Board. After the petition had been filed the contractor voluntarily appeared before the board of county commissioners and asked that the amount be reduced $131,000. After a full hearing by the State Board, the bond issue was disapproved. The county commissioners advertised for new bids and relet the contract for $201,000 less. The original contractor filed suit enjoining the commissioners from re-letting the contract. It was the contention of the Tax Board that the contract was not a completed contract until the bonds were approved or the time for taking the appeal had elapsed. The local court sustained the position of the Tax Board and the contractor appealed the case to the Supreme Court of Indiana and that court affirmed the decision of the lower court.

Supreme Court on Effect of Board Decision

We take the following from the opinion of the Supreme Court:

"The court holds that the alleged agreement entered into between appellants and appellees March 29, 1921, was tentative only and contingent upon the action of the board of tax commissioners upon the petition objecting to the issue of bonds, and, such boards having granted the petition and disapproved the issue of the bonds, that such agreement did not ripen into a consummated contract. It follows that the provisions of section 201 of the Tax Act as amended became a part of the tentative agreement entered into by the appellants and appellees on the 29th day of March, 1921, as though written therein at full length. Therefore, the alleged contract in question was not a binding, valid contract which appellants could enforce, notwithstanding provisions of section 201 of the Tax Act as amended, and that the action of the Board of County Commissioners in April, 1921, pretending to cancel said agreement was of no force or effect, for the reason that the action of the state board of tax commissioners in disapproving the bond issue was as complete a rescission of the unconsummated contract as though the contract itself had had written therein a provision that it was subject to the action of the state board of tax commissioners, if invoked according to law, and void, and of no force and effect, provided such tax commissioners disapproved the proposed issue of bonds determined upon by the board of commissioners. The parties to the agreement were not legally competent to enter into a binding contract in compliance with amended section 201 of the act concerning taxation.

O'Connor v. Board, 142 N. E. 858 (86)."

Newton County Gravel Roads

In Newton County a bond issue was appealed to the State Board providing for the building of three gravel roads. Information secured by the Board was that the price was entirely too high. The roads were merely ordinary gravel roads. The bonds were disapproved. The matter was brought up a second time and disapproved again. The county auditor was notified that the Tax Board would disapprove it as often as it came before it until the board of county commissioners would readvertise and receive new bids; the Tax Board felt certain that the price was too high. This, of course, was before the decision of the Supreme Court in the O'Connor case and the contractors had not yet been convinced that when the bonds were disapproved that terminated

their contract. In that county the commissioners advertised for new bids and the contract was let for $32,099 less on three gravel roads.

School City of Indianapolis

In October, 1923, the school city of Indianapolis determined to issue bonds in the sum of $1,650,000 for the building of eight new school buildings. Ten or more taxpayers filed their petition asking for a review by the State Tax Board. A public hearing was had and the State Tax Board found that there was a necessity for the new school buildings and entered a preliminary finding that the school city should adopt proper plans and specifications, advertise for and receive bids, and that if proper bids were received bonds would be approved. The school city accepted the aid of the engineer of the State Tax Board and plans were prepared and in proper time bids were received. The contractors knew that proper bids must be filed; that all bids would be carefully scrutinized and when this was done, it was found that bids for the eight new buildings, all complete, were for $436,000 less than the total amount asked for. Nothing like that had occurred in the city of Indianapolis for many years. The buildings have since been completed and are a credit to the city.

County Unit Road in Vanderburgh County

The past summer the County Commissioners of Vanderburgh County determined to issue bonds in the sum of $325,000 for the building of the Outer Cynthiana Road. The road is less than 9 miles long. Ten or more taxpayers filed their petition for a review of the bond issue and a hearing was had. On a personal inspection of the road it was found that the road was an old pike with a good foundation along most of the road and that the county had just completed several miles of improved road at greatly reduced price. The attorney for the road is a very genial fellow and when the hearing came on all the petitioners for the hearing seemed to have been prevailed upon to remain away and only the secretary of the Evansville Chamber of Commerce and Mr. Sonntag representing the taxpayers' association appeared. The bond issue was disapproved. There can be do doubt that the road can be built for less than one-third the proposed bond issue. The Board of County Commissioners made a new declaration and another hearing has been had and the matter is again before the State Board. This only shows that money spenders are on the job continually and taxpayers must be equally as vigilant.

How Question Can Be Solved

Taxpayers in almost every county in the State have learned that the right given them under the law to appeal from local tax levies and bond issues has been a material aid in keeping down expenses and stopping the reckless expenditure of money. The question of taxation will never be solved until the taxpayers have some voice in controlling expenditures and some effective methods in putting it in force.

Candidates for office are generally very liberal in making promises that they will reduce taxes if elected to office. No sooner do they get into office, than it is quite convenient to forget the promises made, and it is easier to yield to the demands of those who are always ready to urge improvements whether needed or not.

Indiana Taxpayers Association

This organization composed of leading citizens of both political parties has done much good the past few years in taking the lead in many counties in having budgets properly examined and reviewed where proper changes were not made by local officers. This Association has taken the position that the honest official should not object to a review of bond issues and tax levies for if the demands are just there will be no difficulty in having the same approved by the State Board. Mr. Harry Miesse, the Secretary of this organization, has given a great deal of unselfish service in the interest of all the taxpayers of the State and many who in times past have found fault with his work, now realize that the interest of the taxpayers can only be protected by a live, active and vigilant citizenship.

Indiana Farm Federation

This organization has done much work in bringing about a better understanding on the question of taxation during the past year. Its officers have aided in reviewing budgets and examining tax levies and much was accomplished by this organization. Other organizations might well follow the lead of the Farm Federation and Taxpayers Association for there is still much to be accomplished.

Come, let us reason together, is a better guide than stirring up hatred and litigation which many times serves very lit-

tle in bringing about equitable valuations of property.

The Indiana Plan

Has attracted the attention of students everywhere. Hon. Arthur M. Fraser in an address to the Premier at Winnipeg, Canada, called attention to our law and recommended the adoption of the policy of giving ten or more taxpayers a right of appeal on tax levies and bond issues.

Dr. Adam Short made a similar recommendation at Victoria, British Columbia. The Minnesota Legislature considered it during its last session. The Western States Taxpayers Association in its last annual meeting adopted a resolution endorsing the Indiana Plan of controlling bond issues and tax levies. This association included 12 states. Gov. George S. Silzer in his message to the Legislature of New Jersey in 1924 and again in 1925 urged the adoption of the Indiana Plan. In 1925 Governor Silzer said:

"With the increasing tax rate and the constant inflation of municipal budgets and the issuing of large amounts of bonds, it is our clear duty to provide a method to check extravagance and to relieve the taxpayer.

"I cannot impress this upon you too strongly. If the Legislature in its wisdom, can find anything more efficacious than the Indiana plan, I would be glad to have them do so, but experience has shown us that nothing has been as practical in its effect as that plan. Its operation in Indiana has demonstrated its usefulness and efficacy." * * *

"I strongly urge upon you the enactment of a law similar to the Indiana Plan in the interest of the reduction of taxes."

The National Realtors Convention held at New Orleans adopted the following:

"We likewise believe that the so-called Indiana plan for the review and control of local expenditures, when administered by a capable and honest state commission, is more efficient than arbitrary limitations on tax rates imposed by state constitutions."

Has Stood the Test

The endorsements given the Indiana Plan by students of government everywhere is gratifying to the citizenship of this State. Time has brought about a great change. Many who in the past have criticized the law have come to realize that much good has been accomplished. The law will continue to grow more popular as people become better acquainted with its provisions. The State Board of Tax Commissioners by its members and its special representatives is always ready, willing to give ear to any complaints concerning the present law and its enforcement, and welcomes constructive criticism.

Local taxes are always the greatest part of the taxes paid and with the taxpayers' right of appeal on bond issues and tax levies a wide-awake citizenship can practically control its local taxes by the provisions now embodied in the Indiana tax law.

USE OF LIME IN EARTH ROADS

By H. W. Wood, Jr., Highway Department, National Lime Association, Washington, D. C.

(A paper read at the 1926 meeting of the National Lime Association.)

The investigation of the action of lime on road soils was started about 2½ years ago by the National Lime Association cooperating with the University of Missouri and by the U. S. Bureau of Public Roads cooperating with several state highway departments. This investigation has consisted of laboratory work, together with actual field tests, and while the experiments are not yet completed, several things have been discovered which might be of interest here.

In making the lime treatment hydrated lime is thoroughly mixed into the road soil to a depth of 6 ins. by plowing and discing. To obtain the best results the road should be quite dry when the treatment is made, in order to get an intimate mixture. The road is then dragged to the proper cross section and opened to traffic which quickly packs it.

Lime treatment greatly stablizies heavy clay and silt soils. Those soils immediately lose their stickiness and extreme plasticity, becoming granular in structure, which renders them capable of sustaining normal traffic loads without failure when wet.

Up to this point we have been well satisfied with the success of the lime treatment, but lacked a practical test to guide us in making recommendations.

In order to determine this stabilizing effect accurately a series of investigations was conducted at Ohio State University under the supervision of Professor Eno to devise a test for measuring the stability of soils in the laboratory. The soil to be tested is placed in a steel

cylinder 3 ins. in diameter and is forced through a 1½-in. hole in the bottom by means of a plunger, the load being applied in a universal testing machine.

When the soil holds a definite percentage of water, the load required to force the soil through the hole is a measure of its stability, or its resistance to deformation under load.

On several clay soils tested by this method a lime treated soil holding 30 per cent of water showed twice the stability of the untreated soil holding only 25 per cent of water. In view of the fact that most clay soils fail under traffic when holding about 25 per cent of water, an increase in their stability in this range of wetness may often prevent a failure of the road. It will be seen that there the untreated soil with 25 per cent of water would fail under traffic, while the lime treated soil containing 5 per cent more water would remain smooth and unrutted. That is exactly what we found in the actual field tests.

There are several practical uses for lime treatment of soils. On the back road in the country, where the traffic is not heavy, and where a hard surface road would be too expensive, it seems advisable to treat the troublesome clay sections with lime. By thus keeping these sections hard and firm at all times, many miles of road will be kept open to traffic in rainy weather and after the spring break-up.

Where the traffic is heavy enough to warrant a better road, the subgrade may be treated with lime and the surface covered with a thin layer of crushed stone or gravel. Without the lime this thin layer of surfacing material would soon sink into the clay and disappear; but with the increase in stability and loss of plasticity due to the effect of the lime, the thin layer of gravel or crushed stone will remain on top. This will result in a saving of 5 or 6 ins. of gravel or stone.

It is often a great help to use lime around a construction job or on a farm to dry up mud holes or to prevent them from forming. Hydrated lime can be strung along the tracks and the trucks will work it in.

Maintenance on a lime-treated road is simplified in several ways. (1) The soil loses its stickiness and is not picked up by the wheels of vehicles, to fall on the road and form clods. This keeps the road from becoming rough. (2) The increased stability of the soil prevents the wheels of vehicles from cutting ruts after the surface begins to dry. (3) The lime-treated road dries out faster and can be dragged many hours sooner than the road without lime. (4) The treated soil mulches more easily under the drag, making it easier to obtain a smooth riding surface.

Another possible use of the lime treatment is in connection with aviation landing fields. When a new field is established there is generally some grading to be done and this leaves the clay exposed. It is believed that a shallow lime treatment will eliminate the stickiness of the soil in these spots, allowing it to remain in place, undisturbed, when planes taxi over it, thus facilitating the growth of grass. The lime will also act as a fertilizer in promoting the formation of sod. We are contemplating such a test on the air port in Cleveland, Ohio, this summer.

Test roads are being built in Wisconsin this summer using a thin gravel surface over the lime-treated subgrade. This work will be done by the Maintenance Section of the Wisconsin State Highway Department.

The University of Illinois is building several test sections near Champaign this summer to determine the value of lime treatment preparatory to oiling earth roads. It is expected that the lime will stabilize the soil, and at the same time prevent the emulsifying of the oil by the clay. Both of these should lengthen the life of the oiled surface.

In Missouri and Virginia sections are being treated with lime to obtain further information concerning its use on earth roads without the addition of any surfacing material. In Ohio another short section of subgrade for concrete pavement has just been completed, and the tests in the laboratories at Ohio State University are progressing. With the results of all these tests compiled, together with the results already obtained in previous tests, definite recommendations for lime treatment of earth roads, subgrades and landing fields can be made.

This project has now been brought out of the experimental stage, for the new test will enable us to recommend the amount of lime required on any soil. With some knowledge of local conditions as to grade, location and drainage, we can tell how deep the treatment should be.

HIGHWAYS AND COUNTRY LIFE

(Editor's Note: The following editorial article entitled, "Roads and Rubes," was published in a recent issue of the Minneapolis Daily Star.)

Reliable estimates indicate that the United States will spend more than $1,000,000,000 on the building and maintenance of rural roads during the year 1926.

This means the disappearance of the "rube" from American life. You may be able to find him on the stage, in vaudeville, in the movies, or between the pages of alleged humorous magazines, but not on the farms.

The "rube" is a product of isolation and the spending of one billion of dollars for rural roads means an end of isolation. The American farmer from now on lives on a main traveled highway.

When the day's work is done he is only a few miles away from entertainment. If he prefers to sit by his own fireside he may read his daily paper delivered by the rural routes, get his daily market reports over the radio, or listen to the best music and lectures that America can offer anyone.

His children are seldom more than twenty minutes away from an excellent high school. There they are being trained in all the social graces, taught the fundamental principles of culture, and living a life as broad and beautiful as that enjoyed by any of the city children. On commencement day it is impossible to distinguish between the youths from the farms and those from the city.

The co-operative marketing associations have taugh him the art of working with other men. The good road makes it possible for him to attend frequent meetings, participate in the discussions and become a part of the busy world of thinking and action.

Rural roads put him in easy touch with distant markets. If his local merchant can not supply him with the goods he wants a couple of hours' drive will bring him to a city of 20,000 or more where he can buy anything he wants.

The modern farmer is not easily imposed upon. He is a poor customer for gold-brick merchants. Bankers' figures show that the average city dweller is much the easier victim of the con man.

Improved rural roads mean consolidated schools, less loss in crops, advantageous marketing. The hard-surfaced road has done much to give the American farmer his opportunity as a business man.

It is true that the rural church has had hard sledding, but the farmer can reach the village or city church with greater ease over good roads than he could get to the rural church of a few years ago through the mud.

Good roads make good citizens. The election booth is seldom more than five minutes away from the kitchen door and the farmer is voting, and rapidly learning his political lessons.

One billions of dollars spent for rural roads means that the American farmer is now living as close to the world as the city dweller. He no longer lives alone, astride his plow. He is on a highway where "the race of men go by."

NOTES ON STATE HIGHWAY ORGANIZATION AND ADMINISTRATION

By Robert N. Waid, Chief Engineer Examiner, Department of Auditor of State, Columbus, Ohio.

(Editor's Note: The following notes pertain to the States of Indiana, Illinois, Michigan and Wisconsin, and are from an article by Mr. Waid in "Highway Topics" of recent date.)

The last session of the General Assembly of Ohio named a committee consisting of six of its members, to make a study of the road situation in Ohio. This committee is composed of Senators R. E. Hempel, L. G. Collister, John S. Edwards and Representatives W. E. Baxter, Finley M. Fleming and F. W. Liles. The purpose of the committee is to make a comprehensive study of the present laws pertaining to road construction and maintenance, together with the problem of financing and department organization, and to recommend such changes as are believed to be in the interest of public welfare. Its recommendations for improving the situation in Ohio are to be made to the Legislature, which will convene next winter.

The committee has been hard at work during the past year familiarizing itself with the many-sided problem in Ohio. Its deliberations now center on the question of, "What are we going to do about it?" Knowing that anyone who will can usually profit from the experience of others, a brief trip was taken into four of our neighboring states during the

month of February. State Highway Engineer Harry J. Kirk and the writer were asked to accompany the committee.

Following the return to Ohio, Senator Hempel, who is chairman of the committee, asked that the information gathered at the four State Highway Departments visited be made available through the medium of "Highway Topics" for all those interested in the improvement of our own conditions. The principal features of their laws relative to organization, duties and finances, together with their usual methods of procedure, are here given.

Indiana

The Highway Department of Indiana is in charge of a State Highway Commission consisting of four members. Not more than two may be of the same political party and no two members may be from the same geographical section of the state. The commissioners are appointed by the Governor for a four-year term and one new man comes on the board each year.

The highway commission is responsible for all highway policies and for the administration of the state highway law. The State Highway Director is employed by and is answerable to the Highway Commission. The Highway Director, subject to the approval of the commission, selects all his subordinates, fixes their salary and assigns their duties. The employes of the highway department are not under civil service.

All state road work in Indiana is financed from motor vehicle registration fees and the gasoline tax. All registration fees go to the state. Of the 3 cts. per gallon gasoline tax, 2 cts. go to the state and 1 ct. goes back to the local taxing districts—three-fourths to the counties and one-fourth to the municipalities. Out of this fund the state appropriates enough money to maintain the 4,000-mile state system and then uses the balance for such new construction as may be considered most urgent. The state issues no bonds for state road work.

There are 4,000 miles of highway on the state road system of Indiana. In addition to the state system of roads there is a definite county road system of 37,600 miles. All but 60 miles of the 4,000-mile state road system is improved with a gravel type, or better. The majority of the 37,600-mile county road system is gravelled and about 7,000 miles of the 31,600-mile township system is improved with gravel.

Practically all new construction on the state system is 18-ft. concrete pavement. The state buys the cement and furnishes it to the contractors. "Conditional" bids are taken so that the contractor can indicate his choice and can protect himself against the award of more work than he can handle. The engineer's estimate is not made public until after all bids are read.

Illinois

The Division of Highways is a unit of the Department of Public Works and Buildings. The Director of the Department of Public Works and Buildings is appointed by the Governor, with the approval of the Senate, for a term of two years. The Superintendent of Highways, who is also the Chief Highway Engineer, is directly in charge of the Highway Department. A Board of Highway Advisors of five members is appointed by the Governor. Their function is advisory only and they have no administrative duty or authority.

The Director of the Department establishes the organization of the Division of Highways, selects the employes and fixes their salary and duties. Technical employes are not under civil service.

Funds for both the construction and maintenance of state roads are secured from the receipts of two state bond issues which total $160,000,000. The first bond issue for $60,000,000 was voted in 1918. The second issue for $100,000,000 was voted in 1924. Bonds are sold only as fast as funds are required. The first issue is to be paid off by 1944, the second by 1958. Funds to retire the bonds come from the proceeds of automobile registration fees.

There is no gas tax in Illinois. The registration fee from automobiles averages about $9.90 per vehicle and totaled about $13,000,000 in 1925. Cook County pays about one-third of all motor vehicle fees. About 4 per cent, or 400 miles of the 9,800 mile state road system, is located in Cook County. All motor car registration fees go to the state.

The law fixes the salary of the Director and the superintendent of Highways at $7,000 and $6,000, respectively. Salaries of all technical employes are fixed by the Director.

The State Road System comprises 9,800 miles. The State pays all costs of every description for the construction and maintenance of the state system. There are no property assessments. In

addition to the state system of 9,800 miles, there is a county system of 17,000 miles. The highway department has nothing to do with either the construction or maintenance of this secondary system. There is very little road improvement in Illinois on roads which are not on the state system.

Bids for new construction are taken on four types of improvement as required by law. Practically all roads are awarded on the concrete type. The state does not publish or make known its own estimate of cost either before or after bids are taken. The state furnishes the cement to the contractor. The contractor is paid on a unit price basis for the actual amount of work which he performs.

The state is liable for the maintenance of the entire state system as well as for the construction. Very little work is done in maintenance of the dirt sectioins of the state system, except to oil them. Maintenance work on the improved part of the state system is not extensive, as practically all roads have been constructed since 1919, and are of concrete type. Less than 40% of the state road system is improved.

There is a State Rural Traffic Police organization to enforce motor vehicle laws. The force consists of 80 men. It operates under the direction of the Highway department.

The cost of administration, engineering, supervision and material testing, and all overhead charges, will average about 6¼% of the total highway expenditures.

Michigan

The Highway Department of Michigan is in charge of a State Highway Commissioner who is elected by vote of the people for a term of four years. He appoints all his assistants and also an advisory board. The advisory board meets one day a month and is for the purpose of helping to determine highway policies. Members of the advisory board are paid $10.00 per day, plus expenses when in session. The highway commissioner is responsible for all phases of the highway work and administration.

In 1919, the state issued $50,000,000 in bonds for road construction. The bonds run for 10, 20 and 30 years. In addition to the bond issue money, the counties paid about 20% of the cost of construction on the state roads from 1919 to 1925. The bond issue money has been mostly spent and road work is now financed from a gasoline tax and automobile registration fees. The galonie tax is 2 cents per gallon and it all goes to the state. The automobile registration fees average something over $13.50 per vehicle. Out of the registration fees a flat sum of $6,000,000 goes back to the counties on the basis of the number of vehicles registered. The state gets the balance of the fund.

The State Highway Commissioner is paid $7,500 per year. The Deputy Commissioner, whom he appoints, is paid $6,000 per year. A lump sum appropriatioin is made for the personal service and maintenance of the highway department. Within the appropriation available, the highway commissioner creates positions and fixes salaries at his discretion.

There are 7,000 miles of road on the state trunk line system. The state now pays all costs for construction and maintenance on the trunk line system. Up until 1925, the counties had paid about 20% of the construction cost of the state roads. In addition to the state system, there is a county system of 15,000 miles. Before 1925, the state paid 25% of the cost of building the county roads.

Michigan now derives its road construction funds from the gasoline tax and automobile registration fees. Bids are ordinarily taken on only one type of improvement. Ninety per cent of the construction work is the concrete type. The state furnishes cement to the contractors. Michigan did about one-fourth of its paving work in 1925 by force account. In 1925, over $2,000,000 was spent by the state for right of way. This expenditure was largely around the big cities, particularly Detroit(where superhighways are being constructed.

There is a state traffic police which operates under the State Commissioner of Public Safety.

Wisconsin

The Highway Department of Wisconsin is under the direction of a State Highway Commission of five members. The Dean of the College of Engineering at the University of Wisconsin and the State Geologist are ex-officio members of this commission. The other three members are appointed by the governor for a six-year term. One new man is appointed every two years. The Highway Commission appoints the Chief Highway Engineer and a Secretary to the Commission. The Chief Engineer, with the approval of the Commission, appoints all subordinates in the highway department.

Technical employes are not under civil service.

All state funds for road work in Wisconsin comes from the gasoline tax and automobile registration fees. The galoline tax is 2 cents per gallon. The automobile registration fees average about $13.00 per vehicle. Ten per cent of the money thus collected goes into a state "free fund" to be used by the state in closing important gaps on the state trunk line system, in building roads in state parks and about state institutions, and in connecting state institutions to the nearest trunk line road. The balance of the fund is divided between the state, counties, townships and municipalities. In addition to these funds, the county may issue bonds for construction on either the state or county systems. There are no special assessments against abutting property on the state system. Milwaukee County contributes about one-fifth of the total automobile funds.

The salary of all employes of the Wisconsin Highway Department is fixed by the state highway commission.

There are now 10,000 miles of road on the state road system. The counties are charged with the maintenance of the state system. If their work be done to the satisfaction of the state, the county is reimbursed by the state for the cost of labor and material.

The state may pay the entire cost of new construction. The law provides, however, for the counties, if they choose, to pay such part of the construction cost of new state roads as may be agreed upon between the state and county. In addition to the state system, there is an 11,000 mile county system and 57,500 miles of township roads in the state.

Road construction funds come from the gasoline tax, automobile registration fees and county bond issues. Bids are taken on only one type of pavement. Practically all work is concrete. The state has classified all bidders as to ability to handle work and refuses to accept bids from any one whom they believe incompetent to handle the job under consideration. The state furnishes the cement to the contractor. The engineer's estimate of cost is not made available to the contractor before the date of sale.

It is evident from a comparison of the states under consideration that there are some features of law and policy on which they are in substantial accord. It should be borne in mind, however, that conditions in Ohio are, in some respects, far from parallel with conditions in Indiana, Illinois, Michigan and Wisconsin. The Legislative Committee is anxious to learn all the facts obtainable before reaching a decision. As a result, their final conclusions will likely merit the hearty support of a majority of those interested in improved highway laws for the State of Ohio.

TREND TOWARD BETTER WATER SUPPLIES

By Wellington Donaldson, of Fuller & McClintock, Engineers, 170 Broadway, New York, N. Y.

(A paper before the League of Virginia Municipalities.)

There is undoubtedly a steady trend toward better water supplies in all parts of the country, a trend which dates back many years but which has been gathering impetus with increasing population and the general improvement in living comforts.

The dominant factors which give force to this movement for better water supplies are several. First might be mentioned the increasing pollution of streams and watersheds from which the supplies of municipalities are derived; second, are the concerted efforts on the part of health officials in combating water-borne disease with results so gratifying as to lead to the sanguine hope that typhoid fever and allied diseases may eventually be banished from civilized communities. Third, might be recognized the effect of promulgation of standards of water quality, as exemplified in particular by the U. S. Treasury standard designed to apply only to interstate carriers, but in effect acting as leaven to local administrative control and supervision of water supplies. Lastly, we should not forget that the general public itself is being educated to demand water supplies not only free from danger of causing disease, but supplies which are attractive and inviting as to appearance, taste and odor. That this changing attitude of the public is not confined to urban communities is shown very well by the program now on foot by the American Automobile Association to have labeled or placarded along the principal highways of the whole country those rural water supplies which are acceptable and safe to drink. Some of the state boards of health have taken active leadership in this very excellent work which is doing much to make the public more discrimi-

nating in regard to its drinking water, and is incidentally educating the rural population to an appreciation of these matters.

With respect to the purification of surface water as from streams, ponds and lakes, for removing bacterial pollution, mud, stain and objectionable forms of life, the primary agency is of course filtration. Recent estimates place the number of public water supplies in the United States at approximately 9,000. Of this number some 600 supplies are filtered, or roughly about one in fifteen. During the last year or two there have been notable additions to the ranks of cities having filtered water supply. There is for instance, Detroit, Sacramento, Cal., Charlotte, N. C.; Cambridge, Mass.; Wheeling and Fairmont, W. Va., etc. In the state of Virginia might be mentioned the works at Norfolk, and Richmond, Charlottesville, Bristol, Pocahontas, St. Paul, Appalachia, Danville, Dante and Catawba. Large filter installations are now nearing completiion for Buffalo, Kansas City, and Providence, while filters are projected at Knoxville, Nashville, Chicago, and many other places.

Besides work for the purification of polluted, muddy and colored surface waters, there is a growing tendency towards the purification of ground waters. Many supplies from driven wells contain amounts of dissolved iron and manganese which result in rust water, staining of clothes and plumbing fixtures and there is a growing demand for purification of such supplies. A notable addition to the list of such plants is the one completed at Memphis last year to handle a daily demand of about 20 million gallons. A number of smaller works for iron removal have been built in Ohio and adjoining states within the past two years, and the western states as well.

The softening of hard water supplies by means of lime and soda is gaining in favor in those sections of the county where soft water is not available from natural sources. People seem disposed to pay for the slight additional expense incurred in getting rid of the troubles incident to hard water, such as stoppage of heaters, difficulty in washing, etc. Recent additions to the list of softening plants are Benton Harbor, and Flint, Mich.; Newark and Shelby, Ohio; South Pittsburgh, Pa.; Miami, Fla.; Springfield, Ill.; Topeka, Kansas and Austin, Texas, besides some minor installations.

In connection with softening of municipal supplies there has been lately a revival of the idea of recarbonating the softened water in order to get away from the incrustation of filter sand, pipe lines, meters, etc., which has always been troublesome in connection with softened water. The old Winnipeg softening plant, built in 1904 and later abandoned included the recarbonation feature which afterwards became nearly forgotten until revived by the Columbus studies and is now applied in the softening plants at Defiance and Newark, Ohio; Oklahoma City, Austin, Texas and Miami, Fla. The method is variously carried out either by producing carbon dioxide from the burning of coke in special furnaces or by the utilization of spent boiler gases after suitable scrubbing processes.

As to improvements in the art of filtration, there are no radical changes or developments to record with perhaps the exception of the method devised by H. W. Clark of the Massachusetts State Board of Health where impregnation of the sand beds with aluminum hydroxide takes the place of continuous alum application, as commonly practiced. This idea has not found extension elsewhere so far as known. There has been in fact many improvements made in the design of filtration plants within the last few years but such improvements relate mostly to means of securing better coagulation, constructional details of filter underdrains, various equipment such as controllers and gages for furnishing more dependable control of operation. These matters while attracting considerable attention among plant operators and designers are after all technical details which I assume are of no special interest to those in this audience.

It may be of interest to record here that of the two general types of filtration plants in use the newer works of recent years have nearly all been of the rapid sand types as distinguished from the older method known as the slow sand filter. The suitability of the slow sand filter for particular localities is well recognized, but the greater flexibility of the rapid sand filter to meet varied water conditions has given it a lead in popularity over the old slow sand method.

The pollution of many of our principal rivers utilized as sources of water supply for a large population has brought very prominently to the front the question of permissible loadings to which various purification processes may be safely subjected. It is unfortunately obvious in some localities that the water supply is so polluted that the usual pro-

cesses of purification such as sedimentation, single filtration and chlorination do not provide a sufficiently safe insurance at all times. An extension of the purification processes is needed to provide a larger margin of safety. Thus we see at Albany, with its supply from the Hudson River, rapid sand filters being installed ahead of the older slow sand filters. At Philadelphia where similar intensities of pollution of raw water occur and where "roughing" filters have been used for some years recommendations have been made for double filtration by installing efficient rapid sand filters ahead of the existing slow sand filters.

Two of the Ohio cities use double coagulation in tandem settling basins as a means of meeting conditions of overloading and securing efficiency from existing works.

Along with the growth of a public demand for better quality of water supply has come a clearer appreciation of the need of competent supervision over water purification works. It is being realized that the quality of water furnished communities is too important a matter to be intrusted to any except responsible persons properly trained and experienced in their duties.

In line with the trend towards a better class of operators might be mentioned the movements already established or on foot to give to filter operators a better and broader training. I refer to the annual conferences of filter plant operators held in Ohio these past four years under the egis of the State Board of Health. Similar conferences have been held in North Carolina and are being organized in other states. Texas has for a number of years maintained an annual school for water works operators in connection with the state university and the South Western Water Works Assocation.

In regard to sterilization methods which are directed to the killing of bacteria by chemical or other means, as distinguished from their removal by filtration, it may be said that liquid chlorine today is almost universally employed, although a few of the older hypo-chlorite installations remain in service. The apparatus available for feeding liquid chlorine has been improved with resulting saving in annoyance and maintenance expense. Into the equipment field, formerly occupied by a single manufacturer some strong competition has appeared lately, resulting in patent litigation with a final decision yet to be heard from.

Attempts have been made to introduce installations for electrolytic productioin and control of chlorine, at the water works, but the business has assumed no great magnitude to date.

One idea in connection with chlorinatioin which has attracted recent attention is that of "superchlorination" which refers to the use of relatively large doses of chlorine, stated to be efficacious in detroying objectionable odor and taste due either to certain classes of industrial waste or to microscopic organisms. Somewhat along the same line is the idea of double chlorination or "split" dosing, best exemplified by the New York City practice in connection with its impounded supplies. This may be called "making assurance doubly sure."

Another form of sterilization which has recently been revived after an inactivity of several years is the Ultra Violet Ray treatment. Recent installations of this apparatus have been made at Horton, Kansas and Bereia, Ohio, both small supplies. The only other municipal water supply installation is at Henderson, Ky., installed in 1916 and not now in use. The method to date has found its greatest utility for small installations such as on the Great Lakes steamers and for swimming pools and bottled-water and ice plants.

Along with the improvement of quality in water supply there is arising a demand for better materials for water distribution systems which will be less affected by the action of water in delivery to consumers. This feeling is reflected in the increased use of cast-iron pipe with cement lining and the substitution of brass and copper services for those formerly of galvanized iron and lead.

There is one feature of water supply that has in the last year or two attracted considerable attention and wide discussion, namely, the addition of iodine salts for the prevention of goitre. It seems well established that this disease is due to iodine deficiency in the diet. Prophylactic treatment in the earlier stages by administration of iodine has been recognized and practiced for some time, but the city of Rochester inaugurated in 1923 dosing of the public water supply with sodium iodide as the most effective means of reaching quickly a large population having goistre symtoms. The propriety of a municipality undertaking medication of its population by means of a public water supply has evoked much discussion. Proponents of the idea take the ground that goitre is endemic to such an extent in certain reg-

ions of the country, particularly in the northern belt along the Great Lakes and westward and in the mountain regions of the United States as to constitute a grave public health problem which justifies this method as the quickest and surest way of reaching the greatest number of people. Antagonists of the Rochester experiment, on the other hand, say that iodizing of the water is not the best and most efficient method of reaching the affected population but that it may be better done by local or state control of the iodine content of table salt and by individual medication, by means of iodized tablets or candy, of school children among whom the symptoms are most prominent.

Following Rochester's example the water supplies of Sault Ste. Marie, Minneapolis and one or two smaller commuities are being iodized.

A glance at the quantitative aspect of iodine treatment gives one a new conception of the meaning of homeopathic doses. The human requirement for health is stated to be not over six grains of iodine per capita per annum, an amount easily acquired in non-goitrous regions through the medium of food or drink. In the Great Lakes region where goiter is very prevalent, the water supplies have been found to contain, say 1 to 5 parts of iodine per billion by weight. Rochester by applying about 7 lbs. of sodium iodides per million gals. raised the iodine content of its supply to a maximum of 50 parts per billion during a two weeks period, and this small concentration was regarded as sufficient, when applied twice a year, to give protection against goiter. For continuous daily application it has been stated that O. 1 lb. of sodium iodide per million gals. is amply sufficient to supply the iodine deficiency. This quantity is only one-tenth to one-thirtieth the dose of chlorine customarily applied for sterilizing water. It might be helpful to recall also that an ordinary natural water contains some 800 lbs of dissolved chemical substances per million gals.

In connection with the betterment of water supplies and improvements in the art of purification, there might be mentioned here a noteworthy forward step recently taken by the American Water Works Association in publishing a Manual of Practice which represents the collaboration of about 300 workers in the water works field, including plant designers, chemists, operators, biologists and works executives. This first edition naturally holds many imperfections and errors but it is regarded as a good start towards standardizing this important field. This handbook is recommended as being of considerable interest to administrative heads of municipalities as well as to those actually engaged in water works practice.

TREND OF MOTOR VEHICLE LEGISLATION

By Russell Huffman, Secretary, Motor Vehicle Conference Committee, 366 Madison Ave., New York, N. Y.

(A paper read at the 1926 meeting of the National Highway Traffic Association.)

It must be kept in mind that the laws affecting motor vehicles are scarcely 25 years old. Twenty-five years ago such laws were in force in only a few states, and they were extremely few in number. The greater proportion of motor vehicle legislation has been enacted during the past 15 years. Because it was a subject with which the lawmakers were unfamiliar, and because there have been so many different legislative bodies enacting these laws, it is quite natural that there should be a great lack of uniformity, and, in some instances, unfair regulation. When the above facts are carefully considered we are forced to come to the conclusion that, after all, things are not in as chaotic a condition as they might have been. The tendency at the present time is toward a much greater uniformity and this tendency promises to rapidly materialize during the next five years. This movement is now making rapid strides, even though the results are not readily observable in some phases of motor vehicle regulation.

Legislative and Regulatory Authority Over Motor Vehicles

There are three jurisdictions here in the United States which have authority to regulate the use and operation of the motor vehicle through legislation. These jurisdictions are the Federal Government, the 48 state governments and the municipal governments, which number several thousand. Because of this peculiar situation it can be easily understood why motor vehicle regulations have been so lacking in uniformity and so particularly diversified in their application. As yet, the Federal Government has enacted no laws regulating motor vehicles, although Congress is at the present moment seriously considering the passage

of a bill designed to regulate bus and truck lines operating in interstate commerce. The several thousand municipalities have, however, through their authority to pass ordinances, enacted a great many regulations, particularly those applying to traffic rules, which have become no small part of the total mass of rules and regulations affecting the motorist. However, the most important motor vehicle legislation has been enacted by the state legislatures, and it is to this type of legislation that I expect to devote a greater part of this discussion, in my attempt to give a brief review of the situation.

Increase in the Volume of State Legislation

In the past five years there has been a marked increase in the number of bills introduced in the state legislatures designed to regulate or to apply to the motor vehicle. In 1821, with 42 state legislatures meeting, the total number of bills introduced approximated 2,000; in 1923, when the same number of legislatures were in session, this number was 2,200; in 1924, with only nine states meeting in regular session, this total was 600 bills. However, in 1925, with 42 state legislatures again meeting, the number had increased to approximately 2,500. During the present year of 1926, which is known as a "light year," because only nine states have held regular sessions, the total number of bills introduced approximates 750. If the 1926 average is maintained in 1927 there will be at least 3,6000 bills introduced and considered by state legislatures which relate to the motor vehicle.

A relatively large proportion of these bills have been enacted into laws. In 1921 this amount was about 400; in 1823, 450; in 1924, about 150. In 1925, this number increased, due to the fact that most of the states were in session, to 563. The 1926 records are not complete, but the indications are that there will be approximately 150 new motor vehicle laws added to the state statutes.

Trend of More Important Phases of Motor Vehicle Legislation

The field of motor vehicle legislation is so broad that it would be impossible to give you anything more than a brief review of what has taken place during the past few years with reference to the more important subjects. Briefly, this tendency has been as follows:

Registration and license fees have gradually increased, particularly with reference to trucks and buses. There has been a marked tendency to increase the gasoline taxes.

With reference to size, the tendency has been to gradually decrease the allowable width of buses and trucks. Likewise, there has been a growing tendency to reduce the gross weight limitation permitted buses and trucks.

The tendency, with reference to speed regulations, has been to permit a much higher rate, and this has been particularly true during the past two years.

Motor vehicles operating for hire, commonly called common carrier vehicles, have been more and more regulated by the state governments, and this tendency has developed quite rapidly during the past few years.

State lawmakers are rapidly seeing the need of requiring all drivers of motor vehicles to be examined and licensed before being permitted to drive, and this has resulted in the enactment of drivers' license and examination laws in many of the states.

Certificate of title laws, designed to prevent the sale of, and aid in the recovery of, stolen motor vehicles are becoming more and more common.

There has been much agitation during the past few years for compulsory automobile liability insurance, or, some method of fixing the owner's responsibility for accidents caused by his motor vehicle. This agitation, however, has not resulted, as yet, in the enactment of much legislation on this subject.

Equipment of motor vehicles, such as lights and brakes, more especially headlights, has been receiving a great deal of attention at the hands of the legislators. Headlight regulation is still in a very unsatisfactory condition.

There is a decided advancement toward uniform traffic laws and rules of the road, and while, apparently, still in a chaotic condition, they are gradually being unified through the process of educational work carried on by the motorists and their organizations.

In the matter of enforcement, the tendency has been toward the application of much stricter penalties and more rigid enforcement of the laws, especially those directed toward the careless and intoxicated drivers.

Discussing these more important phases of motor vehicles legislation in greater detail, we find that some interesting facts are developed.

Registration and License Fees

The first state registration fee law was enacted in 1901. By 1915 every state in the union had levied such fees. Naturally, the tendency has been toward an increase in these fees, especially with reference to commercial cars, although during the past two years this tendency has greatly diminished because of the rapid adoption of a new form of tax, namely, the gasoline tax. There is a great diversity among the states in the methods of assessing motor vehicle registration fees. In fact, there are about twelve different bases now being employed in determining passenger car fees and nineteen in determining commercial car fees. Some states charge a flat rate; some base the fee on horsepower; some on weight; some on capacity; some on value, and some on a combination of the above factors. It probably will be a long while before all the states have adopted a uniform method of assessing their registration fees. During the past two years only three states have materially changed their method in this respect. The most marked increase in registration fees affects buses and trucks. Figures compiled by the Bureau of Public Roads in 1923 showed that in 29 states the fee paid for the average truck was more than twice as great as the average fee paid per passenger car. No doubt this average has increased since that time.

This increase in registration and license fees can be shown by making a comparison of the increase in the number of motor vehicles with the increase in the total amount of fees paid. In 1915, there were 2,445,666 vehicles registered in all the states, paying total fees amounting to $18,245,711. In 1925, there were 19,954,347 vehicles registered and the total of the fees paid was $260,619,621. This shows that in the ten-year period the number of motor vehicles increased approximately 8⅛ times while the registration fees increased approximately 14 1/3 times. This increase is also very definitely shown by comparing the average fees per car in 1915 with those in 1925. In 1915, the average was approximately $7.45 per car, while in 1925 it was approximately $13.05 per car or almost 100 per cent increase.

Gasoline Tax

One of the most outstanding developments in motor vehicle legislation during the past few years has been the popularity and spread of the gasoline tax. This form of tax has been seized upon by the state legislators as the easiest method of assessing taxes on the users of the highway. The chief argument used in favor of the gasoline tax is that it is the best method yet devised which enables the state to charge the motorist for the amount of use he gets out of the highway, since the amount of the tax will depend upon the number of miles he has traveled. The first state to enact a gasoline tax was Oregon in 1919, and so rapidly has this spread that at the present time 44 out of the 48 states have such laws. Recent figures issued by the Bureau of Public Roads show that the average gasoline tax in the whole United States is 2.26 ct. per gal., and that the average consumption per car is 430 gal. per year. The total amount of gasoline taxes collected in the United States during 1925 was $146,000,000. One need not be a prophet to predict that the motor vehicle users will, within the next five years, be paying annually $250,000,000 in gasoline taxes.

The adoption of the gasoline taxes has not been followed by a decrease in the registration fees, as might be expected. The tendency has been to make them an additional tax rather than a substitute. In only three states has the adoption of the gasoline tax resulted in a decrease in the registration fees.

Disposition of Motor Vehicle Tax Funds

One of the most noticeable features in connection with registration fees and gasoline taxes has to do with the disposition of the funds collected from these sources. In former years a considerable portion of the total amount collected was used for purposes other than highway development. The tendency now is to use these funds purely for highway purposes. In 1921 the sum of approximately $18,000,000 out of a total of $133,000,000 collected from registration fees and gasoline taxes was diverted from highway purposes. In 1925 out of a total of $260,000,000 collected from registration fees, all but $3,300,000 went to highway purposes. Of the $146,000,000 collected from gasoline taxes in 1925 about $11,000,000 was used for other than highway uses. Adding this to the $3,300,000 which represents the amount of the registration and license fees not used for highway purposes, you have the sum of approximately $14,000,000 out of the total motor vehicle revenues from these sources, namely, $406,000,000, which was not used for highways. This is less than 4 per cent and indicates how well the motoring public is watching the expenditure of funds collected from them. No

other form of special tax revenue, in my opinion, has been so closely kept to its purpose. Within the next few years, no doubt, changes will be made in the state laws so that every cent collected will be used for highway development.

Highway Development

Highway development, while not a part of motor vehicle regulation, is so closely associated with the general subject that no review would be complete without briefly indicating the rapid progress being made in the construction of our highway facilities. Figures compiled by the Bureau of Public Roads show that in 1904 the total highway mileage in this country was 2,151,379 miles. The total number of miles in that which could be classified as "surfaced highways" was 153,530, representing 7.14 per cent of the total mileage of all highways. In 1925 the total amount of highway mileage had increased to 3,002,116 miles and the amount of "surfaced mileage to 495,000 miles. Sixteen and one-half per cent of the total mileage may now be classified as surfaced highways. There can be no doubt that this percentage will rapidly increase when we take into consideration the fact that we have been spending approximately a billion dollars annually for highways during the past few years.

Size, Weight and Speed

At the present time three-fourtss of the states have enacted laws regulating the width and height of motor vehicles. These regulations, of course, only affect buses and trucks. In 1921 only one-half of the states had such regulations. The greatest width permitted in any state at the present time is 108 inches, and the narrowest width is 84 inches. The majority of the states have fixed the width limit at 96 ins. and the height at 12 ft. 6 in. It must be noted, however, that the tendency is toward the reduction in the permissible width.

All the states but three have enacted regulations fixing the weight of vehicles operating over the highways. In 1921, 40 states had such requirements. These requirements, generally, not only fix the gross weight and capacity weight permitted on four wheels, but also the axle and per inch width of tire weight. The gross weight limitation ranges from 30,000 lb. to 18,000 lb., the average being about 24,000 lb. Practically every state has a provision in its law which permits state and local highway officials to decrease this weight allowance when the weather conditions have softened the roads so that it would be inadvisable to permit heavy vehicles to operate.

One of the noticeable movements during the past two years with reference to weight limitations is the tendency on the part of the highway officials to base the weight allowance upon the character of the highways over which the vehicle is to operate. This is known as the classification of highways. Under this method all highways are divided into four classes—terminal highways, highways connecting industrial centers, intermediate highways and local highways. Under this plan the heavy loads are confined to those highways constructed to carry such weight. While no state has yet enacted such a law several of the state highway officials are using this plan to fix the weight permitted over certain of the state highways. There is no doubt but that this plan has great merit, and it may go a long way toward solving the difficulties as regards highway weight regulations which exist now in a great many of the states.

During the past five years there has been a very noticeable tendency toward increases in the legal speed permitted in the states, both within cities and outside cities. In 1901 when the state of New York passed its first speed laws, the limits were fixed at 8 miles per hour in built up sections and 15 per hour in open country. No state at the present time has such low restrictions. The average now is at least 30 miles per hour in open country, and some states have fixed it as high as 45 miles per hour. In 1925, the legislatures of ten states changed their speed laws, and in each case this change represented an increase in the allowable maximum speed. This tendency is due largely to the fact that it has been found necessary to speed up traffic in order to relieve the highways of congestion. This method has been found exceptionally successful in large cities where certain streets have been set aside for fast traffic and in certain states where some of the main highways have been loaded with an exceptional heavy amount of traffic.

It is interesting to note at this time that one of the very recent developments with reference to speed regulations is the tendency toward a minimum speed limit rather than a maximum limit. There is considerable agitation at the present time for minimum speed laws among some of the state highway officials, and at least one state has enacted a law which prohibits the operation of a

motor vehicle on the highways which cannot maintain a certain minimum speed.

Common Carrier Regulations

The regulation of motor vehicles can be classified into two divisions—namely (a) the regulation of the physical operation of the vehicle, and (b) the regulation of the business of operating motor vehicles for hire. This latter class has to do with what is commonly known as common carrier regulations which has been placed largely under the jurisdiction of the state public utilities bodies. The regulations of the physical operation of motor vehicles is largely in the hands of the commissioner of motor vehicles or similar administrative officer.

During the past few years there has been a decided tendency toward state regulation of the business of operating motor vehicles for hire. In 1914, Pennsylvania passed the first law of this kind. At the present time 37 states have enacted laws regulating buses to a greater or lesser degree, and 30 states have laws regulating trucks. In the case of truck regulation, while 30 states have enacted such laws, not all of them attempt to regulate the complete operation of the business, especially as it concerns rates and tariffs. In 1925, eight states enacted new laws of this character. There is no doubt but that the year 1927 will see several more laws of this kind placed upon the statute books.

During the past two years there has been a growing desire on the part of the state public utilities bodies to increase their jurisdiction not only over the business of operating, but also, over the physical operation of the vehicle. This is evidenced by the fact that at least one state public utilities body has issued, in the form of regulations, a complete set of specifications regarding the size and length of body, the equipments and lights to which all buses must conform before they will be permitted to operate. Recently, the States of Massachusetts and Connecticut have issued regulations which include requirements relating to the kind of lights and other equipment of buses which have heretofore been left to the Motor Vehicle Department.

Driver's License and Examination Laws

In the interest of safety many of the states, eighteen in all, have enacted laws, which requires that every operator of a motor vehicle shall be licensed before being permitted to drive his vehicle over the highways. Thirty-six states require all chauffeurs to take out licenses. In many of these states an examination is required before the license is issued. The purpose of the examination is to determine the physical and mental qualifications of the driver with reference to his ability to handle a vehicle and his ability to understand the highway traffic rules. These laws have been quite generally accepted, not only by the automobile industry, but also by the whole motoring public, as one of the most important factors in the interest of safety. This was clearly brought out by the deliberations of two meetings of the National Conference on Street and Highway Safety, known as the Hoover Conferences, and at both these Conferences driver's license and examination laws were recommended as one of the most important means of bringing about a reduction of highway accidents. There is no doubt but that the next few years will find the enactment of such laws in practically all of the states.

Certificate of Title

Certificate of Title Laws have been enacted in about twenty of the states. The purpose of these laws is to prevent the disposal of stolen vehicles, and to aid in the recovery of such vehicles. In a state where such a law is in force the purchaser of a second hand car is protected because he knows that the seller of the car must give him a Certificate of Title proving his ownership, and that such ownership is recorded with the State Motor Vehicle Department. It is pretty generally agreed by the whole automobile public that such laws, when adopted in all of the states, will make it practically impossible for thieves to carry on any traffic in stolen vehicles. As an indication of how rapidly these laws are being adopted, it should be noted that eight states enacted them in 1925. Many more states will, no doubt, accept this plan during the meeting of their legislatures in 1927.

Compulsory Automobile Liability Insurance

One of the newest forms of legislation to come before the motoring public is compulsory automobile liability insurance. Many people believe that every owner of a motor vehicle should be required to carry liability insurance in order that his responsibility to pay damages be established in case he is involved in an accident. The first bill of this character was introduced about six years ago and so rapidly has its popularity spread that in 1925 no less than 26 state legislatures were considering such measures. Out of this number only one

state has enacted such a law, namely Massachusetts. The Massachusetts law will not go into effect until January, 1927, so it can be correctly said that compulsory insurance is not in operation in any state in the United States at the present time. Time does not permit to enter into a discussion of the pros and cons of this insurance, but it should be remembered that there are few facts or data in existence in the United States at the present time which bear out the contentions of the proponents that it is a beneficial plan or that it will operate successfully. It would be very advisable for the motoring public to withhold their affirmation of this kind of insurance until actual facts are at hand to prove its success. It should be noted that practically all insurance companies are opposed to this plan and national automobile organizations, such as the American Automobile Associations, National Automobile Chamber of Commerce and National Automobile Dealers Association have emphatically opposed the enactment of such legislation.

Motor Vehicle Equipment

The most important phase of automobile equipment, so far as legislative regulation is concerned, is that which relates to lights. At the present time there is a great difference of opinion among lighting experts as to how this question should be settled. Because it is a highly technical problem and because the average law maker is unfamiliar with such problems, we have on the statute books a great many confusing laws on the question of headlights. There is a decided lack of uniformity among the states as to these requirements, and, in some cases, a great deal of trouble has been caused motorists traveling from one state into another. This problem has been solved to a great extent in the Eastern Atlantic section of the United States through the uniform rules and regulations adopted by the Eastern Conference of Motor Vehicle Administrators, an organization which consists of the administrative officers of eleven of the eastern states, extending from Maine to Virginia. The problem of motor vehicle headlights is now being studied by the technical and engineering organizations connected with the automobile industry, and no doubt a satisfactory answer will be found within the next few years.

Probably the next important phase of motor vehicle equipment, so far as regulation is concerned, relates to brakes. All but two states have laws touching on the subject of brakes, but in most of these laws no mention is made of any technical requirements. Most of the laws merely state that the brakes must be "adequate and sufficient." For the past two years, however, there has been a tendency on the part of some of the state administrative officers to require that the brakes be capable of certain performances before being permitted to operate on the highways. In order that a fair test be made, a section committee of the American Engineering Standards Committee is now at work on a safety code for brakes, in which certain definite requirements are set up for braking performances based upon the speed of the vehicle and the condition of the highway surface. The experience data upon which this code is based was compiled by the Bureau of Standards from actual tests made on several hundred cars. If this code is adopted, the state administrative officers will have something to guide them in their examination and investigation of brakes which will be based on fair standards of performance.

There has been little change during the past several years in the state laws relating to other equipment, such as mufflers, mirrors, signaling devices, etc. Practically every state requires that all motor vehicles have such equipment, but few attempts have been made to specify the design. This has been left largely to the manufacturers.

Traffic Regulations

The most noticeable lack of uniformity, which directly affects the motorist himself, has to do with traffic regulations or the so-called "rules of the road." Every one knows that there is a great confusion in the state laws regarding such regulation. Even within the individual states, there is a great lack of uniformity, since many municipalities have authority to regulate traffic within their limits.

As a result, motorists going from one state to another are continually confused because they do not know what traffic regulations are in force. This situation has become so acute that a campaign of publicity has been going on during the past few years in the attempt to bring about some change. So important was this problem that the two National Conferences on Street and Highway Safety held in 1924 and in 1926 give a great deal of consideration to possible remedies and, as a result, the 1926 Conference recommended a uniform motor vehicle code which contained a complete set of traffic regulations. If this uniform vehicle code is adopted by all of

the states this troublesome problem will soon be settled.

Enforcement and Penalties

The past few years has seen a decided tendency on the part of the law makers to inflict heavier and more stringent penalties upon motorists who have failed to heed the laws. There has also been a decided movement toward a stricter enforcement of these laws. One of the most noticeable steps in this direction is the establishment of state traffic police forces in a number of the states. Furthermore, this problem has been handled in the municipalities through the establishment of special departments of police known as traffic departments, and the use of a large number of policemen in each of the larger cities for traffic duty alone. The courts, too, have become very active in the enforcement of the laws, and penalties are being inflicted much more readily than ever before. Many states have recently placed very heavy penalties upon the careless and intoxicated driver. The need for this can readily be seen when an examination has been made of the number of accidents caused by these two classes of drivers.

Organization

The attitude of the motorist has rapidly changed in recent years until at the present time the great majority of motor vehicle users have come to realize that they are, more or less, responsible for the type and character of regulatory legislation. The first motor vehicle laws were drafted by legislators who had little knowledge of the needs of the motorist or the conditions regarding motor vehicle operation. The past few years has seen a decided change in this respect. Motorists now realize that it is their duty to educate the law makers to the needs of sound motor vehicle regulation. As a result of this, the more recent laws are much more reasonable and much more capable of enforcement.

The present time finds the industry and the motoring public very well organized. The manufacturers have a strong national organization; the dealers are organized in practically every state and also are represented by a national organization; the owners of motor vehicles, now numbering practically twenty millions of people, not only have their local automobile clubs and state organizations, but also are under the guidance and leadership of a strong national organization, namely the American Automobile Association. Just recently the bus operators of the country have been organized into a national group which is affiliated with this association. At the present time truck owners comprise the only class of motor vehicle operators which is not well organized, and it is hoped that the next few months will see them united into an effective national group. It can be safely said that the motoring public and the industry is entering into the year 1927, when forty-seven State Legislatures convene, well prepared to guide and direct the character of motor vehicle legislation.

SEWAGE TREATMENT PROGRAM AT CHICAGO

By Langdon Pearse, Sanitary Engineer, The Sanitary District of Chicago, Chicago, Ill.

(A paper read before the Western Society of Engineers.)

The sewage treatment program of The Sanitary District of Chicago has been developed since 1909 and tested in its various phases. The Engineering Board of Review in its report of December, 20, 1924, has summarized the situation most excellently and presented a document which has been styled by some foreign engineers as the most valuable report since the Royal Sewage Commission ended its labors. At the risk of repetition, I will mention a few facts so you may understand better the progress made by the Sanitary District in the last 15 years and the program ahead.

It was early evident that the sewage treatment program for the Sanitary District involved a study of both domestic and industrial sewage problems. Consequently a testing station was operated at 39th St. Pumping Station from 1909 to 1915 on domestic sewage. This was followed by the study of the Packingtown wastes from 1911 to 1918, the results of which have been published in two lengthy reports. Next came the investigation of the tannery wastes from 1919 to 1922, and last the study of the corn products wastes at Argo from 1921 to date.

As a result of these investigations the importance of the industrial load on the sewage problem became manifest.

TABLE 1—LOADS OF CHICAGO SEWAGE AND INDUSTRIAL WASTES

Year	Human	Population Industrial Equivalent	Total
1920	3,000,000	1,500,000	4,500,000
1930	3,710,000	1,700,000	5,410,000
1945	4,785,000	2,000,000	6,785,000
1955	5,500,000	2,200,000	7,700,000

Progress has been steady. The negoti-

ations with the packers finally reached a deadlock. Consequently the Sanitary District went into the Federal and State court asking for an injunction to restrain the discharge of water into the Chicago River. In the lower State courts, the Sanitary District was beaten. An appeal has been taken. In the case of the tanneries, the program involves the removal of suspended solids at the tannery, with the treatment of waste mixed with the city sewage at the North Side and West Side Sewage Treatment Works.

At the Corn Products Refining Company, thanks to the hearty co-operation of the Chief Engineer, Mr. J. J. Merrill, and the other officials, some remarkable results have been obtained. Our first result was to indicate the value of automatic sampling of effluents, to tune up the operation of existing equipment. After the possibilities of activated sludge and trickling filters had been studied, the suggestion was made by the operating officials that a way might be found to "bottle up" the troublesome wastes and reclaim them. Briefly the bottling up process means the recirculation of the washwater in the early processes where the starch is separated, and after concentration, the filtering out of the solids. On a small scale the results have been encouraging. The company is now extending its testing to its entire factory at Pekin—and if successful, will equip the Argo plant. Under the agreement between the Sanitary District and the Corn Products Refining Company, this work is carried out without cost to the Sanitary District. The indications are that from 85 to 90 per cent of the pollution can be removed. In a factory grinding 75,000 bushels of corn a day with a loss of say 3 to 4 per cent, recovery of 2,000 to 2,500 bushels of material means a very appreciable saving. If all goes well, this will be one of the most remarkable achievements in waste recovery of recent years.

The treatment of domestic sewage in the Sanitary District has also progressed. Since the first plant was built at Morton Grove in 1914, the Des Plaines River, Calumet, Glenview and Northbrook plants have been constructed (Table 2.) At the present time the Sanitary District is operating five sewage treatment works, handling the sewage of over 195,000 people, besides carrying on the investigation of the corn products waste.

In these plants we are using, under technical control, Imhoff tanks, trickling filters and activated sludge. We are further investigating the dewatering of activated sludge and its digestion combined with Imhoff sludge.

Our testing and operating experience gives us data upon which to predicate our larger work. Such experience is unusual, in that the designing engineer seldom has the opportunity to follow up the operation as closely as we have done. The importance of the sludge problem has been pushed upon us. In this we have endeavored to proceed cautiously. One very interesting development has been the combination of an Imhoff tank, with an activated sludge unit, whereby the excess sludge is returned to the sludge digestion chamber of the Imhoff tank and digested with the primary sludge. Although this necessitates a larger slude digestion chamber, it has afforded a ready way of reducing the volume of the activated sludge and of furnishing a digested sludge which will readily air-dry. Furthermore the preliminary settling permits a decided reduction in the amount of air.

In our studies of the sewage treatment program, during the past 17 years, we found the territory shaped up into five major projects and a number of minor projects. The major projects are as follows:

North Side—Activated sludge plant under construction. Serves 800,000 population as of 1930, residing in territory

TABLE 2—SEWAGE TREATMENT WORKS IN OPERATION BY THE SANITARY DISTRICT OF CHICAGO.

Plant	Year Finished	1925 Population Handled	Type of Plant
Morton Grove	1914	1,468	Imhoff tank.
	(a)		Covered trickling filter with splash plate distributors.
Des Plaines River	1922	58,000	Activated Sludge plant—with fine screens (1 1-16x 2 in.), 4 aeration units, settling basins, dewatering equipment.
Calumet	1922	134,000	Imhoff tanks, 30 units.
	(b)		In addition 2 units of activated sludge, also 0.74 acre trickling filter with secondary tank. Sludge dewatering equipment.
Glenview	1924	1,063	Imhoff tank and trickling filter.
Northbrook	1925	710	Imhoff tank and trickling filter.

(a) Trickling filter added in 1919.
(b) Trickling filter and activated sludge added in 1923.

north of Fullerton Ave., south of Cook County line, west of Lake Michigan.

West Side—Inhoff tank plant under design. Serves 1,850,000 population as of 1940, residing in the territory north of Main Channel, south of Fullerton Ave., from Lake Michigan to Harlem Ave., also some of the Des Plaines River and Salt Creek villages.

Southwest Side—Probably activated sludge. Will serve 1,230,000 population as of 1940, residing north of 87th St., south of Main Channel, east of Summit, west of Lake Michigan.

Calumet—Imhoff tank plant in operation. Serves at present 134,000 population, residing south of 87th St., east of Ashland Ave., north of Calumet River, and west of Lake Michigan.

Packingtown—Probably activated sludge. Serving packinghouses in area known as Packingtown.

Of the major projects, our most recent studies indicate the desirability of combining the Packingtown waste with the domestic sewage with treatment at the Southwest Side.

Our present program is definitely outlined in the construction program approved by the Chief of Engineers, U. S. Army, for the period 1925 to 1929. Under this program (Table 3), for the major projects we have undertaken to finish the North Side Sewage Treatment Works by the end of 1927, and build the West Side Treatment Works by the end of 1929. In addition the waste from the Corn Products Refining Company is to be disposed of and some work done on the Packingtown wastes.

The North Side Sewage Treatment Works is over 40 per cent completed. This is an activated sludge plant to handle a dry flow of 175 million gallons per 24 hours from 800,000 people as of 1930. Briefly, it consists of a pumping station, and blower house, coarse screen, grit chamber, preliminary settling basins (20 to 30-minute period) and three batteries of aeration tanks, each containing 12 aeration units, 420 ft. long, 34.75 ft. wide, with 15 ft. water depth on the plates. Each battery has an operating gallery and 10 settling tanks of the Dorr type, 77 ft. square and 15.75 ft. deep. The aeration period is taken at 6 hours. The air required was taken at 1 cu. ft. per gallon. A 50 per cent overload can be carried. In the works are also two large buildings, one for the offices, laboratory and return sludge pumping, the other for the heating plant, repair shops and locker rooms.

The excess sludge will be pumped through a 14-in. force main to the West Side plant, some 18 miles away. There we propose to mix the activated sludge with the incoming sewage and deposit the suspended matter and sludge in the Imhoff tanks for digestion. An additional sludge capacity is provided for this. The tests at Calumet indicate that this procedure is sound. As a reserve a few lagoons will be provided.

This is a change from the recommendation of Messrs. Eddy, Fuller and Hatton in 1922, whereby lagooning was proposed. I believe the new procedure sound. Waste land along the Main Channel in the amount of 950 acres has already been reserved for the dumping of the air dried sludge.

The cost of the North Side project when completed is estimated at $15,000,000 for the treatment works and $12,800,000 additional for the intercepting sewers.

The West Side treatment works will be

TABLE 3—SUMMARY OF SCHEDULE OF CONSTRUCTION—1925 TO 1929

Project	Estimated Cost	Date of Completion
DesPlaines River		
Extension of Works	$ 320,000	Nov. 1927
Broadview-Bellwood Sewer	400,000	Dec. 1926
Calumet		
Extension of Works	3,693,000	July, 1929
Additional Interceptors	1,125,000	July, 1929
North Side		
Sewage Treatment Works	14,415,000	Dec. 31, 1927
Intercepting Sewer	11,718,000	Dec. 31, 1927
North Branch Pumping Station	1,300,000	Oct. 31, 1928
Industrial Wastes		
Stockyards Screening Plant	1,500,000	Dec. 1927
Corn Products Treatment	250,000	Dec. 1926
West Side		
Treatment Works	10,000,000	July, 1929
Intercepting Sewer	13,300,000	July, 1929
Pumping Station	1,325,000	July, 1929
Miscellaneous Treatment Works and Sewers	1,712,000	
Dredging Calumet River	1,500,000	
Rehabilitation of Pumping Stations	387,000	
39th St. Conduit Extension	2,187,000	
Bridges and Highways	8,287,000	
	$73,419,000	

Of this $11,674,000 had been expended on July 1, 1925.

the largest Imhoff tank plant in the world. We have chosen this type as we believe it affords the most satisfactory way of settling the sewage and reducing the sludge to a minimum for easy drying. An air mixing device will thoroughly mix the North Side sludge with the incoming sewage. The sludge handling has required study, because upward of 2000 cu. yds. of air-dried material must be handled at times. The first contract will be advertised in May. The cost of the West Side project is estimated at $14,000,000 for the treatment work and $16,000,000 additional for the intercepting sewers.

Of the minor projects, many are only in process of crystallization. Some planning is under way for Calumet City and Oak Forest. A most important work is the enlargement of the Des Plaines River activated sludge works and the gradual additional of drying beds and more trickling filters at Calumet.

In addition there are the necessary intercepting sewers and pumping stations for the major projects, and a number of minor interceptors which will bring additional territory to the Calumet, Des Plaines, North Side and West Side Works.

For the future the development in the Des Plaines River Valley will be studied and consideration given to the outlying communities to decide how they will eventually best fit into our program.

For the program beyond 1929, we have in mind the Southwest Side Sewage Treatment Works, which will be the last of the large projects to be undertaken. This will serve about 1,230,000 human population and in addition will treat the wastes of Packingtown equivalent to the sewage of over 1,100,000 persons. This will probably be an activated sludge plant. We felt it was wiser to allow some time to elapse before starting on such a plant, which when completed, would be the largest of its kind in the world. We not only desired operating data on our own North Side Works, but also the operating experience of Milwaukee and Indianapolis. The disposal of the sludge will depend largely on the development in the meantime. The cost of the project, including both intercepting sewers and treatment works is roughly estimated at over $20,000,000.

In the main, the sewage treatment program of the Sanitary District may be summed up as a vigorous effort to remove practically all of the settling solids from the sewage and treat biologically enough of the sewage to maintain the desired condition in the Illinois River with the established diversion. The analysis of the Engineering Board of Review by the Committee on Sewage Disposal clearly shows the importance of preventing sludge deposits.

The construction of the dams in the Illinois River by the State will alter the conditions of re-aeration. Consequently, as part of our program we are carrying on the most extended sanitary survey of the Illinois River yet undertaken, to establish present condition and check the work of the previous survey in 1921-1922, made jointly by The Sanitary District of Chicago and the United States Public Health Service.

The control of the Illinois River and its cleaning up is a problem in sewage treatment without precedent on the scale required. A number of interesting questions have arisen on which research is needed, such as the effect of the nitrates on algae growths, the value of supplementary aeration in the canal or stream and the effect of storm overflow. In all the research and study, looms up the need of the maintenance of the diversion and its value to take care of contingencies. Only actual careful following of the operation of the program in detail will determine the final operating requirements.

The study of the Illinois River has further shown the importance of the pollution from the cities and villages along the river, and indicated the extent of the industrial pollution in the metropolitan area of Peoria and Pekin, an equivalent of well over a million people.

To aid in determining the future of the water supply of Chicago and the neighboring towns, an extended study was made for over a year by the United States Public Health Service jointly with The Sanitary District of Chicago, the Chicago City Board of Health and the State Boards of Health of Illinois and Indiana. This is being compiled. The data obtained will authoritatively indicate the condition of the lake and the sources of pollutiion.

Filtration of the water supplies taken from the lake in the vicinity of the Calumet River is imperative. The treatment of the sewage now entering the Calumet River from Indiana is necessary to relieve the load on the water filtration plants, and on chlorination. The filtration of the water from the 68th Street and Dunne Cribs seems highly desirable. However, the purification of the water

for the water systems by filtration is a matter which has to be handled by the Water Department of the respective cities interested.

ENGINEERS DECIDE TO DO SOMETHING ABOUT IT

(Editor's Note: For many years this magazine was greatly interested in the compensation of engineers. We finally dropped the subject feeling that the engineer had been "kidded by experts" for so long that he would never really do anything more than "trouble deaf Heaven with his bootless cries." Now it appears, however, that we were mistaken for the engineers in the service of the cities of Chicago and New York have decided to do something more than bemoan their fate. We append hereto an editorial from the "Professional Engineer" for August, 1926, entitled "Low Salaries of Engineers in Municipal Employ." The "Professional Engineer" is the official journal of the American Association of Engineers, an organization that will be remembered by many as one founded to help the salaried engineer but which always backed down when on the verge of accomplishing something really useful. Just when the life preserver was in reach of the sinking engineer some very ethical gentleman would remark: "Naughty, naughty/ You mustn't help that man. It isn't ethical/" Then the life preserver was jerked away from the poor cuss and he was left to sink or swim. Even the writer of the following editorial is somewhat troubled about ethics. As we understand it the only really God-for-certain ethical thing the salaried engineer can do is starve to death. But, as we said in the beginning, we dropped this whole subject years ago. Asking the reader's pardon we shall detain him no longer.)

About two months ago the engineers in the employ of the City of Chicago, after *several previous promises* of increases in salaries which were not kept, went on a strike as a protest against the low salaries that were being paid. After *a day's strike* they received their demanded increase.

Recently the engineers in the employ of the City of New York organized themselves into a Personal Service Bureau, and in their advertising literature state that they stand ready to sever their present connections with New York City at any time that some other municipality, corporation, firm or individual desires their services on engineering projects on either a contract or a percentage basis.

Statistics gathered by Arthur Richards, Past Director of District No. 8, and set out in the report of the Committee on Services and Fees of Engineers in Public Service, show that engineers in most of the larger cities are considerably underpaid; in fact, in many cases barely receiving a living wage. (The same fact has been shown at intervals since 1850—Ed. M. & C. E.)

The expansion and development of municipalities to meet the demands of modern society requires the services of competent and highly trained engineers. In order to secure and hold such Engineers they must be paid a salary commensurate with the responsibilities they assume.

The success and reputation of public officials, in this day and age, is depending more and more upon the ability and technical training of engineers employed by them to carry out their program for municipal improvements. However, most public officials fail to appreciate this fact, and why, is more than we can understand.

Without commenting on the ethics (God save us all/ again interposes the editor of M. & C. E.) involved in the action of the engineers of the Cities of Chicago and New York, it is evident that there is a spirit of unrest and dissatisfaction growing among engineers in municipal employ. It is hoped that public officials, the country over, will heed the warning sounded by the action of the Chicago and New York engineers and give to engineers in municipal employment that recognition which is justly due them. If this warning is not heeded then the public will probably witness more demonstrations of the foregoing character in the future.

AN UNCONVENTIONAL VIEW OF "REGULATION"

By David A. Reed, United States Senator from Pennsylvania.

(Editor's Note: The following article is noteworthy because of its authorship. Senator Reed is reputed to be Secretary Mellon's special representative in the Senate. If Secretary Mellon is thinking along these lines ,and that seems a fair inference in the premises, we shall probably hear more objections to present day ideas on "regulation" of public utilities, public morals, etc. Senator Reed wrote

the following article for the August issue of "The Nation's Business," organ of the United States Chamber of Commerce, under the title: "If I Were a Dictator.")

If I were a dictator I would abolish the Federal Trade Commission this morning, the Shipping Board tonight and the Interstate Commerce Commission tomorrow.

Fussy government meddling in other men's business has brought us to the plain inevitable conclusion that it is time for this country to get back to that self-reliant freedom on which Anglo-Saxons have always succeeded.

To take a homely illustration: None of us like to see the grass plots of our public parks trodden bare. Each of us feels a certain sympathy with the erection of signs here and there cautioning people to keep off the grass; but it is conceivable that most of the beauty of the park may be destroyed for everyone by making such signs too big and by sticking them around in too great abundance.

Now that is what I think we are in danger of doing in all our governmental activities in the United States. We are carrying the restrictions too far. We are harassing everybody too much in our efforts to forestall every evil. We are pestering innocent persons too often by our attempts to catch the crook. We are inspecting too minutely; investigating too far. Our government has become too much of a busybody. We have too many regulatory commissions—too much government on every hand.

The average citizen rises in the morning and washes in water furnished by a company regulated by the public service commission. His breakfast is cooked by gas, similarly owned or regulated by the Government. His breakfast bacon has been inspected by agents of the Department of Agriculture to see that it conforms to the pure food law. He rides to work in a trolley or on a railroad whose every action is controlled by various public service commissions.

The first lien on his day's earnings belong to the income tax collector so he must keep his books as directed by the Secretary of the Treasury. The bank to which he goes to make a deposit or get a loan is inspected by the Government and lives in daily terror of the comptroller of the currency. During the day he is visited by a field agent of the Treasury Department who pries into and criticizes his most intimate business affairs and perhaps by a representative of the Attorney General in Washington who subpoenas him to testify before a distant grand jury in another state in a proceeding in which he may have little or no interest.

Towards the end of the day, his wife calls for him in the family automobile, duly licensed by the state government, and they drive slowly home, watching carefully for the signals of the traffic police and stopping on the way to buy a fresh supply of gasoline, on which they pay a government tax of three cents a gallon. After a dinner of beefsteak which has been duly inspected by government agents at the packing house, they go to the movies to see a film which has passed the state censor and finally return home blissfully thinking they are free citizens of a free country.

Business twenty-five years ago in a large measure was run by the men who owned it. There was full and free scope for individual initiative. The man who was assertive, forward moving, daring, put across the schemes he had in view. If he won, he kept his wininngs. If he lost, he paid his losses and started again. Nothing but his own self-interest and a comparatively simple moral code operated to regulate his policies and activities. New businesses were established and grew great almost overnight. Our country's natural resources were tapped as never before and seemed to pour out inexhaustible riches. We were on the upgrade. Economy mattered less than enterprise. We could afford to carry on growing burden of government and we could look unmoved on each new governmental experiment, for whether it succeeded or failed our broadening shoulders were strong enough to bear the cost.

But now, according to the economist we have a different outlook before us. We have ahead of us a considerable period of excessive competition, not only within our own country where a productive capacity beyond our normal needs was brought into existence by the demands of the war, but with other countries which must sell in competition with us if their industrial life is to continue.

Railroads Have Been Hurt

Before we entered upon the present era of wholesale government regulation, our railroads rendered a service that was remarkably fine—the best of all the railroads in the world. They rendered it for a rate that was lower per ton per mile than was charged in any other country in the world. They competed in fur-

nishing service and competition kept the service good and held the rates down. The best young men we had in America went into railroading as a profession for life. The executives of the railroads devoted themselves to the business of railroading and did not spend so much of their time trying to arrange to have the Interstate Commerce Commission made up of men who would be kind to the carriers, as some of them do nowadays. They were quite willing to stand upon their own merits.

Since then, we, meaning the Government, have undertaken to show the railroads how to run their business. We have adopted grandmotherly policies of regulation, so that all of a railroad's income and 80 per cent of its outgo is regulated by some commission or other. As a consequence, the free play of economic conditions has been so throttled that at the beginning of war days, when prices were mounting on all sides, the railroad rates could not mount with them and the roads were almost bankrupt. At the end of the war prices started going down and again the railroad rates could not keep pace downward with them and regulation.

We created this whole bewildering labyrinth of governmental control of railways primarily to protect the public against rebating, discrimination and excessive rates. We could have dealt adequately with the first two by comparatively simple penal laws and competition was much more effective in meeting the problem of unreasonable rates in 1900 than government agencies are today. What the public is chiefly interested in obtaining from the railroads are good service and reasonable rates. I do not hesitate to make the assertion that in seeking to accomplish that object through the Interstate Commerce Commission our efforts have been a complete failure.

We have enacted complicated and cumbersome legislation, setting up costly systems of accounting and requiring the railroads to maintain expensive corps of highly paid lawyers. Enormous clerical staffs, costing millions of dollars annually, are employed by the roads in their efforts to comply with the requirements of the Interstate Commerce Commission to prepare and file reports on every subject under the sun relating to railroads. That commission now receives five thousand reports each day. Much of it is sheer waste. The cost, however, must all come out of rates and the public must pay the bill. I am seeking now to ascertain how many of these reports are of value and how many are practically worthless and I expect to propose measures for curtailing the practice. Many of the reports, I am convinced, could be dispensed with at once without the slightest injury to the public interest. They merely serve the purpose of annoying the railroads, boosting rates to the public and cluttering up the pigeonholes of the Interstate Commerce Commission.

Yet we talk of adding more and more pages to railway legislation. In my judgment, we would do a great deal better to scrap the whole hampering system of governmental interference and trust the men who are the inspiration of American business today, punishing them only when they do wrong and not every day, right or wrong.

A Remedy Is Suggested

I say: Sweep the whole awkward mechanism of restriction out of existence.

Of course, I know the answer to this—that the railroads of the country cannot live unless there commissions, federal and state, stand there today like stilts to hold their rates up. I concede that some of them, the badly financed and poorly operated ones, probably would undergo reorganization but if we want the railroads to be revived and desire to put the able railroad men of the country back on their feet where they belong, we have got to turn them free and let them shift for themselves like other self-reliant Americans.

What I have said about the Interstate Commerce Commission and its relationship to the railroads goes also for the Federal Trade Commission and its effect on business generally. It likewise applies with equal effect to the United States Shipping Board and the restrictive shipping legislation Congress has enacted.

Time was when the American merchant marine dominated the ocean-going commerce of the world. Our fast vessels with their smart Yankee skippers sailed the seven seas and carried the cargoes of all nations. Shippers sought American vessels first because they knew they could get the best service and lowest rates from them. Today we have all but harassed American shipping from the seas. We are doing far more damage to the business interests of America than all their offenses could have caused the community if those commissions had never been created.

The Question of Supervision

Well, what is to be done about it?

The inquiry is a natural one. If we abolish all these commissions and bureaus will we not find our railroads giving rebates, our packers selling bad meat, our movies producing vile films? Aren't these commissions all necessary? The answer, I think, depends upon one's conception of freedom under government. I personally believe that we would do much better to punish the evil doer than to hobble all men so as to prevent their doing evil.

If we wanted to prevent the heinous crime of stealing chickens, I believe I would prefer to punish the proven thief rather than establish a system of registration and licensing and inspection of all poultry. In the same way, I believe we could prevent railroad rate discrimination and rebating just as effectively and far more cheaply and much less annoyingly if we abolished a few commissions and confined ourselves to punishing proven offenders.

Must Think of the Outcome

We must begin not only to take stock of the cost of our vast encroachments upon the freedom of the individual but also to look into the future and try to picture the logical outcome of these efforts to reverse economic law by legislative nostrums. We must go to one extreme or the other. Either all our commercial life must be regulated by governmental commissions or all commerce must be liberated so that natural laws of trade are allowed to have full play. Government meddling which results in protecting one group of industries while leaving others without protection will not be tolerated in this nation. I believe that free competition in every branch of business is the only policy our people will approve in the future.

I strongly endorse the slogan of the party now in power: "More business in government and less government in business."

Some praiseworthy achievements towards carrying that excellent doctrine into practice are being recorded under the present administration but much still remains to be done and we must practice eternal vigilance to guard against the possibility of a revival of paternalistic and socialistic schemes of government in the future. We see these things cropping out from time to time. Some individual or group always has a pet theory to work into legislation, and under certain circumstances of discontent they find a ready response among classes of voters and in the halls of Congress. We have just witnessed a striking illustration of the point I am seeking to make in some of the radical farm legislation considered during the past session of Congress. Unless we can definitely check the tendency to enlarge our federal powers and get back to first principles as they were conceived by the founders of the republic our whole form of government must change.

I realize that mine may be a voice crying in the wilderness. I hardly expect the majority to agree with me today. At some time in the future I am confident they will. All the legislative inventions, however, alluring to the credulous, cannot make the streams of economic law run uphill.

Would Abolish Three Boards

Nothing is to be gained by patching poultices on the things which we know to be fundamentally wrong. And so, as I said in the beginning, if I had my way I would abolish the Interstate Commerce Commission, the Federal Trade Commission and the Shipping Board overnight. That would wipe the slate clean and give us a fresh start. I feel certain it would have a wholesome effect.

MOTORING ON SUMMER SUNDAYS

Mile after mile two lines of cars crawl past each other under the broiling sun—sedans, coupes, racers, limousines, roadsters and touring cars, all crowded to the running boards with hot and tired travelers. The lines move jerkily forward, a few feet at a time, or wait endlessly at crossings, the riders dumb and weary, stolidly enduring the heat.

A stalled car holds up one procession. Its perspiring driver cranks violently on a reluctant motor to the tune of shrieking whistles and horns sounded by impatient motorists held up behind him on the narrow road. A huge truck lumbers along, loaded with wilted young picnickers, scantily clad and hot, but never too hot to be hugged.

An exhausted village traffic policeman scolds angrily at an equally exhausted and very perplexed Italian who drove to the left, although the sign he couldn't read plainly said "Keep to the right." Many cars are pulled to the side of the road and women in wrinkled Sunday finery wait limply under the scant shade while red faced men toil miserably in the oppressive heat changing tires through blinding fumes of gas and dust.

Busy speed cops tear uselessly past the

creeping lines. Incorrigible boys in an ancient flivver take death-defying chances to pass just one more car, always miraculously squeezing back into line again, thanks to somebody else's good brakes and good driving. Another driver equally reckless, but not so lucky, now waits with a crippled car in the ditch for the village towing service.

Children wail while mothers scold and threaten, brakes squeak and horns blare, the little breeze dies off, but the sun beats mercilessly on—

Dear God, and they do it for fun!

—Carol Francis,
in Chicago Daily News.

ROADSIDE MARKETS

Farm produce to the value of over $2,116,000 per month is sold direct to motorists, from roadside markets in the rural districts of the United States, the American Road Builders' Association said recently. The new market for fresh produce has grown to a $25,000,000 annual business for the farmer with the spread of the good roads movement.

The figure includes only the produce purchased direct from small stands operated along the highways, usually by the small truck farmer. The sale of fresh eggs, milk and butter to urban residents who drive to the farm to secure their fresh foods would easily bring the figure to more than $50,000,000 annually, according to the estimate.

The use of modern highways to improve the marketing facilities of the farmer will be one of the subjects discussed in detail at the 1927 Convention and Road Show of the American Road Builders' Association. The meeting, which will be held during Good Roads Week, January 10th to 14th, will be attended by representatives of a great many agricultural organizations interested in the construction of goods roads, according to H. G. Shirley, President of the Association.

"The American farmer is no longer hampered by the necessity for seasonal marketing of his products," Mr. Shirley said. "The construction of good roads has made it possible for him to reach his market at all times, with a speed and economy heretofore unknown. The proper construction of these roads to meet the exact demands of the farmer, however, is a matter of great importance. The American Road Builders' Association urges that all road commissioners, engineers and other officials intimately acquainted with the highway needs of the farmer, attend the 1927 Road Congress at Chicago.

LAND RECLAMATION IN TEXAS

Marked progress in the irrigation and reclamation of Texas land is indicated by the work now going on in connection with Hudspeth County Conservation and Reclamation District No. 1. A well and ditch system of irrigation and drainage is soon to be put in operation there, using electric pumping.

The original land in this district, comprising approximately 20,000 acres, came under the Elephant Butte project and was practically all irrigated by gravity. In the latter part of 1923 a municipal district was formed with headquarters at Fort Hancock in order to provide some means for drainage, bonds being issued to cover the expense involved. The system of drainage and irrigation by pumping finally decided on is the first of its kind to be undertaken on any of the land coming under this project.

A number of wells will be sunk, the average depth being 100 ft. and the average life 50 ft. The water will be pumped from these wells to open ditches and carried over the land for irrigation, any excess being carried by other ditches into the Rio Grande River by gravity.

Immediate plans cover the installation of 30 pumping plants. The pumps will be supplied by the Byron Jackson Pump Manufacturing Co. and will be driven by General Electric motors. The pumping outfits will range in capacity from 15 to 40 horsepower, most of them being the smaller capacities.

The El Paso Electric Company has rebuilt its transmission line from El Paso to Fabens, a distance of approximately 30 miles, to provide the necessary power, and will further extend the line from that point to the southeast line of the project, a distance of approximately 50 miles.

SALESMEN TRAVEL CHEAPER BY AUTO

In four years the operating costs of automobiles have been reduced more than one-third, chiefly because of improved roads, according to figures supplied in a report of the Dartnell corporation, a

service organization for sales executives, says Michigan Roads and Pavements.

In 1920 it cost from 10 to 20 per cent more to travel by automobile than by train, states the report which was compiled through the assistance of 194 firms using automobiles for sales work. In 1922 it was estimated that the operating costs of cars had been reduced to about the same as the cost of train travel when all factors were figured in, 10 cts. per miles.

However, in 1924, the operating cost of the salesman's car had dropped to 6 cts. a mile. Considering that each salesman's automobile travels 10,000 miles per year, a conservative figure, the saving over operating costs in 1922 amounted to the astounding figure of $2,717,200 for the 6,793 cars of these 194 firms alone.

The Dartnell corporation gives this as the reason for lower operating costs: "The extended development of good concrete roads, and the better roads program under way for the year, are changing the whole complexion of operating salesmen with automobiles. We have it on authority that improved roads, during the last two years, have cut down gasoline mileage and tire costs almost one-half in a number of States."

Another important development noted in the report is the increasing tendency for firms to operate their automobile service the year round. Of 187 companies, 163 are enabled to use their automobiles for the entire twelve months because of favorable road conditions in their territories.

FEDERAL ROAD BOND ISSUE SUGGESTED

Representative William P. Holladay of Danville, Ind., is sponsoring a bill to be presented at the winter session of Congress, providing for a national system of hard roads, to be financed by a billion dollar Federal government bond issue.

It is claimed that the proposed plan would not conflict with the present Government program for road construction, which would be continued even if the new project were authorized.

"This bill provides that payment of the bonded indebtedness to be undertaken by the Government may be met in large part by a very small tax on motor vehicles and on gasoline or any other fuel used in and by such vehicles," said Representative Holladay.

The bill provides that for at least 20 miles out from the corporate boundaries of every city of 200,000 population or over the hard-surfaced portion of each roadway shall have not less than four traffic lanes. Paved belt roads around cities to relieve congested sections of through traffic is another provision.

HIGHWAY LIGHTING CONSIDERED IN OHIO

A program providing means for highway lighting will be presented to the next legislature by the Ohio Good Roads Federations.

The program will be revised by the committee on ways and means, appointment of which will soon be announced, under the chairmanship of W. A. Porterfield, of Canton.

The program will permit counties, through the board of commissioners and the state, through the highway department, to enter into contracts for lighting, on the same basis as cities and villages now operate, according to Frank G. Harrison, president of the federation, and W. A. Alsdorf, secretary.

It will not saddle a burden upon the taxpayer, upon local units of government or upon the state but will merely permit communities that want dangerous or congested highways lighted to carry out their wishes.

Illumination of heavily traveled roads, would tend to reduce accidents by showing up dangerous curves, eliminating headlight glare and permitting detection of obstacles in the path of the motor vehicle; add to the comfort of night driving by relieving eye strain; increase night traffic, thereby removing congestion and reducing the cost of shipments; extend capacity of the roads; bring electricity to the country home for light and power, and add to the value of real estate by expanding the cities along the highways and providing electrical conveniences.

ONE FOR THE BOOK

To make possible the holding of the Truckee River (California) highway celebration on the scheduled date, June 10th, it was necessary to open a 0.7 of a mile detour around an uncompleted bridge and overhead grade separation. This involved construction of a temporary bridge across the river.

The Maintenance Department of Di-

vision III assigned the task to Assistant Resident Engineer Clyde Rust with orders to complete the bridge in five days, although it was hardly expected that the work could possibly be accomplished in that time.

Rust gathered a crew and went to work. The bridge was finished on the evening of the sixth day. It is 102 ft. long, 21 ft. wide, with a wheel guard and hand rail. It is founded on four rock-filled timber cribs and has held up under passage of a power shovel and heavy trucks.

The feat of the young engineer was related to the Governor and members of the commission when they passed over the bridge on the initial trip over the new highway.—California Highways.

"THE CLIQUE"

"It is sometimes said of associations, lodges, institutions and other bodies, that they are run by a clique," says A. L. P., writing in the Utah Constructor.

"In some senses this is true, because there is always a little band of loyal followers to any organization who find themselves, as the only ones present at every meeting, solely responsible for the conducting of its affairs. Consequently their names appear quite frequently in connection with the business of the organization and they at once become known as 'the clique.'

"The non-attendant member, who always criticizes their actions, does not seem to realize that the remedy for this situation is in regular attendance at meetings where he has a perfect right to oppose anything 'the clique' may do in opposition to his wishes.

"Sometimes the hard feeling which exists against a clique is absolutely unjustified and if it were not for 'the clique' upon whom the burden of all work invariably descends, the organization would go under."

CLEAN RIVERS FOR MICHIGAN

The prospect of clean rivers for Michigan grows increasingly bright, says "Michigan Public Health."

Conferences begun in January between the various agencies contributing to stream pollution and the state departments of Conservation and Health continued until the latter part of April, meeting a good response. Municipalities were the first to be represented, summoned to Lansing by river basins. Causes, effects, and remedies for the pollution of streams by city sewage were discussed.

Following the muncipalities came the industries that were the chief offenders, sugar, paper, milk, tanning, and canning. With each group were discussed the pollution problems peculiar to their industry, and to each was given a specified time in which to work out the solution.

The conferences gave every indication that much needed action will be taken.

STREET LIGHTING UNITS FOR CHICAGO

With the addition of 7,000 more ornamental Novalux street lighting units, which will be in operation by December 15 of this year, Chicago will have the largest installation of modern residential incandescent street lights of one type of any city in the country.

Three previous orders for a total of 15,500 units have already been installed, which will make a total of 22,500 lights, sufficient to illuminate more than 500 miles of Chicago's streets. All the lighting units have been supplied by the General Electric Company. They consist of 250--candlepower Mazda lamps in alabaster rippled globes, mounted on 12-ft. concrete octagonal poles manufactured by the Chicago Concrete Post Company.

This installation of 22,500 units is the first step in a plan Chicago has under way for relighting the entire city.

ORNAMENTAL STREET LIGHTING

Modern Tendencies in Ornamental Street Lighting, by C. J. Stahl, Manager of the Illuminating Engineering Bureau of the Westinghouse Electric and Manufacturing Company, has recently been published in reprint form. It is an unusual treatise on the subject of street lighting and is profusely illustrated with diagrams and halftones that show the comparisons between the revenue from street lamps and other load builders, the efficiency of small lamps for street light and other commodities such as jewelry, tobacco and soft drinks and other striking comparisons.

THE GENERAL PHASES OF DIESEL POWER APPLICATIONS

By R. H. Bacon, Diesel Engine Division, Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

If any one factor might be suggested to account for the rapid development of the nation's resources and the widespread prosperity of all classes, that factor is power. The speeding up of production through the use of power driven machinery has been carried to a point undreamed of even a decade ago. As a result production per unit of labor has been increased and since the greater interchange of commodities through increased production is really the measure of prosperity, the United States leads the world.

Since power is such an important factor in our national existence, the forms of power development and the economics of that development have been given a great deal of study in all industries. The first step in that development was the utilization of small steam engines and water wheels located at points where power was to be used. Then came the steam turbine with its amazing development which entirely changed the viewpoints on economical power production.

It was soon found that power costs could be lowered through the use of extremely large steam turbines as compared with the use of a large number of small units. This quite naturally led to the building of large power stations and the distribution of power through transmission systems to the point of consumption.

This development has proceeded to the point where practically the entire country is now covered with a net work of transmission systems feeding electrical energy from enormous steam and water power plants.

It would appear that this development has about reached a point where the increased cost of transmission and the cost of supervision offsets the very small increases in efficiency which are now possible in the large steam and water power plants.

Some engineers are inclined to believe that the power of the future is to be that furnished by these large plants interconnected by complex transmission systems. There is, however, another angle of the power problem which, although it has made extremely rapid progress during the past few years, is sometimes overlooked. The new phase in power progress is the Diesel engine.

During the past few years the Diesel engine has become such an important factor in solving the problem of low cost power production that it has been very widely adopted. It has been estimated that at the end of 1925 there were in the United States approximately 3,000,000 horsepower of oil engines in stationary power plant service. Every year has seen an increasing use of Diesel engines and a widening of the field of application.

In the face of the widespread distribution of power from large power stations, it might seem that the Diesel engine could not stand such competition. To those who understand what the Diesel engine is and how it operates, the progress which this prime mover is making is not at all surprising.

In the first place the average small steam power plant turns only 5 to 8 per cent of the heat in coal into useful work. The larger power stations utilize around 15 to 18 per cent of the heat in the fuel and the very latest super-power station transforms 20 per cent of the fuel heat into work. It must also be remembered that the losses in transmission from the point of generation to the point of consumption are considerable, often measuring 20 per cent of a station's output. Then to the actual fuel expense must be added the interest on the huge investment necessary to distribute the power and the cost of the supervision which includes the maintaining of the entire system and the billing of the consumer for the actual power which is used.

One of the first reasons for the application of the Diesel engine is its high thermal efficiency. Engines of this type operate at a thermal efficiency of about 32 per cent which means that the utilization of heat is much more effective than in the largest steam power plant. It is also interesting to note that this economy of fuel is practically the same for a 50 h. p. engine as it is for one rated at 5,000 h. p. This high efficiency in all sizes means that the small industry has at its command a prime mover which is much more efficient than the largest super-power steam station ever built.

In order to understand why the Diesel engine is so rapidly taking its place in industry it is necessary to know something about how this type of prime mover operates.

The operation of a Diesel engine is quite different from the automobile en-

gine. A low grade fuel oil is injected into the combustion space about the time the piston has nearly reached upper dead center. Due to the compression pressure of about 500 lbs. per sq. in., the temperature of the trapped air rises to about 1,000 deg. Fahrenheit and ignition of the fuel charge begins. As combustion proceeds the burning gases expand through the orifice and combustion is completed in the cylinder proper. No explosion takes place and there is no rise in pressure for the gases burn evenly and the expansion is quite similar to steam.

As the piston is driven downward on the power stroke it first uncovers the edge of the exhaust port and the pressure in the cylinder drops to practically that of the atmosphere. The inlet air port is then uncovered and the air which is forced into a manifold on the side of the engine by a compressor which is built in as a part of the engine, rushes out throught the cylinder, blows out the burned gases and fills the space with fresh air. In smaller sizes of engines this scavenging air is compressed in the crank case by the downward movement of the piston and flows from the crank case up through a passage to the cylinder and into the cylinder when the inlet port is opened. The piston again moves up and as it reaches its highest point fuel oil is again injected through the nozzle.

This type of Diesel engine is known as the 2-cycle, airless injection type. It differs from the 4-cycle engine in that there is a power stroke in each cylinder at every revolution of the crank shaft. In some types of Diesel engines the fuel is injected directly into the cylinder with the aid of compressed air at about 1,000 lbs. pressure. There are many arguments advanced as to the relative merits of the two systems but such a discussion has no bearing on the subject at hand.

The progress in the design of Diesel engines has been such that these engines are very simple to operate. The lubricating system, for instance, is completely automatic and there is not a single point on the engine which is not reached by pressure lubrication. The lubricating oil is pumped into the main bearings, flows up through the hollow connecting rods and up into the top of the pistons and then back down into the crank case where it is picked up by a pump and passed through a strainer and cooler, which are a part of the auxiliary equipment of such a plant. The stream of oil flowing through the piston keeps the piston head cool. In smaller sizes of engines the piston cooling feature can be safely eliminated.

One hand wheel is used for starting and stopping the engine. When the wheel is thrown over to the start position the starting air comes on and then as the wheel is brought back to the run position the flow of oil to injection pumps begins.

Another hand wheel which is located in the governor may be used to change the speed through a considerable range. This is used when it is desired to parallel two or more Diesel electric units or where the drive requires a speed variation.

With Diesel engines of this type it is quite a common operating experience to produce a kilowatt hour with a fuel cost of one-half cent. Since the engine is easy to operate, a very small operating force is required as compared with a steam plant and so the cost of operation is usually around one cent per kilowatt hour. Even with the fixed charges on the investment and the maintenance cost added the total cost of power usually ranges from 1.25 to 1.50 cts. per kilowatt hour.

The Diesel engine power plant also has some other important advantages aside from low power costs that are attractive to industry. The Diesel engine may be started at a moment's notice and there is no fuel consumed when the engine is shut down. In the steam plant the boilers must be kept banked if the plant is to be started up on short notice.

In the Diesel plant there is no chimney, smoke or ashes and no coal or ash handling apparatus required. The oil fuel which is used is highly concentrated with comparatively little bulk for the heat units it contains. It is easy to transport, offers no difficult storage problem and is easily handled by means of pumps. Furthermore there is an adequate supply of well oil in sight to say nothing of the vast untouched supply which is stored in oil shales.

Since the Diesel engine uses water for cooling purposes only and in comparatively small quantities there is no water supply problem of any consequence.

It should not be inferred that there is not an economic place for the steam plant in small sizes as well as in large stations. Many industries require process steam and in such a case the economical method is to generate power from the

steam in reducing it to the pressures required for process work.

Even in such a case, however, the Diesel engine has its place since it is possible to put one or two Diesel units in such a plant in order to make the power production cost entirely independent of the process or heating requirements. Sometimes in this case the Diesel engine carries a definite part of the load and then the steam units furnish the balance of the power requirements in accordance with the demand for process steam.

In metropolitan areas there is no question but what the large super-power steam plant can produce power at a cost, plus the cost of distribution, which will make it possible to give the consumer power rates which are as low as the cost with Diesel engines. Even in such cases, however, the Diesel engine may be installed as a standby unit or may be used for the purpose of reducing the peak load demands on the power sytem and hence reduce the rates where such rates are based on demand charges.

The Diesel engine of today offers extremely interesting possibilities in reducing the cost of power in practically every industry, on the railroads for motive power drive and for application to portable and semi-portable machinery such as the equipment used in the excavating, dredging and material handling fields.

Before a solution of any particular power problem can be intelligently reached it is necessary to consider all available forms of power which might be used and to overlook the Diesel engine in making such a study is to eliminate one of the latest and most efficient types of power producing apparatus.

Improvements in the design of Diesel engines, together with improved manufacturing methods, have made it possible to install Diesel engines which will give dependable service over a long period of years and which will rapidly pay for themselves by lower power costs.

THE CITY TRAFFIC PROBLEM

By W. P. Cottingham, City Engineer, Gary, Ind.

(A paper read at the 1926 Purdue Road School.)

From New York to Los Angeles—from Duluth to Jacksonville—the people are clamoring for a solution to the traffic problem, and none of them are willing to be prevented from building up congested high value districts. Buffalo, Detroit, Toledo, Cleveland, Chicago, St. Louis, New Orleans, Indianapolis—all our great commercial cities are paying the price for congestion. Many are hopefully watching the experience of Washington, D. C., where precedent was recently upset and the traffic problem placed in the hands of an engineer. A great many accomplishments have been recorded in the past year, but the weak spot was found to be the lack of opportunity to enforce the traffic rules laid down. The engineer brought forth many useful ideas, but met with considerable difficulty in enforcing them. This might turn us back to the question, "Do the people—who are the city—want traffic regulation?" Of course they want it for the other fellow, but until they decide they need it for themselves it is a job for the policemen to force them into it.

The American Engineering Council has announced the organization of a nation-wide movement among engineers to solve the growing traffic problem. A general committee is to serve as a clearing house of ideas between the engineering societies and the National Conference on Street and Highway Safety. Their announcement says: "In every community in the United States the traffic problem is acute in some form. The country is beginning to realize that this problem is essentially of an engineering character. This is because, in most places, the local police have reached the limit of accomplishment and still the problem continues to grow with increasing speed and seriousness. Under these circumstances, it behooves the engineering profession to undertake to meet its responsibility in the matter."

Congestion is invariably the cause of our traffic problems. If there was no congestion on our streets we usually believe there would be no problem; but the fatal traffic accident does not occur in congested traffic as often as in the clearway where speeding occurs. Reckless driving must be curbed through the exercise of police power but congestion must be remedied through the application of engineering knowledge and common sense.

Improperly controlled traffic in the United States costs $2,000,000,000 a year or $20 a year for each man, woman and child in the nation, according to estimates made in official reports. That is the price the country is estimated to pay in loss of life, accidents, loss of time

through congestion, depreciated real estate values and in other ways for the lack of properly developed traffic facilities and their control. This estimate, which is four times the waste caused by fire losses annually, is based on data gathered by the committee on metropolitant facilities of the national conference on street and highway safety.

What does congestion cost the public? A recent study in Chicago develops the fact, quite logically, that time valued at $26,250,000 could be saved annually by the citizens of the city if one-half hour could be gained in the time spent in transportation. In this estimate it is considered fair to count the time of various classes of traffic as worth so much per hour, and to allow a reasonable length of time to make a given trip. What time is consumed in making the trip over and above the reasonable or expected running time may be valued at fifty cents per hour for pedestrians and passengers, $1.25 for horse drawn vehicles, $2.50 for automobiles or motor trucks, and $5.00 per hour for street cars. A motor car with driver and two passengers will gain time valued at $1.75 per day if a reduction of 15 minutes each way is made in a daily journey to the city. In 300 days the value of time saved the car and occupants is $525. At this rate 50,000 cars entering and leaving the city daily will be saved time valued at $26,250,000 yearly.

It was considered remarkable a few years ago that St. Louis could approve a bond issue amounting to $87,000,000 for developing their major street plan, yet in view of figures like those given for Chicago it would seem a most logical procedure. Through the development of the major street plan in St. Louis the traffic problem is being relieved—adequate street widths, to accommodate the present and future traffic, are being secured. The street improvements are being designed to carry the traffic expected both in respect to number of vehicles and weight of loads. They are building safety into the streets in all ways known to them and are giving to the citizens of St. Louis the benefit of their sincere attempt to apply engineering knowledge to the solution of the traffic problem.

Some Attempted Solutions

Two present conditions are set down in this discussion as permanent—as known quantities. Automobile speed is not going to be cut down; rather it is likely to increase. And the number of automobiles is going to keep climbing; the saturation point is still far off. There is no use fighting these conditions. They must be accepted, and the building of safety into streets and roads must be planned accordingly.

In cities like Chicago it will require the separation of heavy and light traffic, pedestrian traffic and traction and railroad lines; the creation of through routes protected by traffic signals; subways under streets or bridges over streets at schools or other important pedestrian crossings; smooth paving of streets; widening and straightening of streets; placement of safety islands at dangerous crossings; removal of obstructions from the streets; and a traffic signal to give the pedestrian an equal chance with the automobile to cross in safety.

Los Angeles has proceeded during the past year to put some of these practices to the test and in addition to reducing its automobile fatalities in 1925 they have speeded up traffic 60 per cent and trolley traffic 30 per cent. If time is worth anything in California the saving should be in the millions. At any rate, lives are worth saving and this report indicates a justifiable claim for the saving of 29 lives in the year despite an increase of 15 per cent in the number of autos operated.

In accomplishing this the metropolitan traffic control system has been operated to regulate pedestrian as well as vehicular traffic. Stern traffic and parking rules have been enforced. Tunnels have been built under busy boulevards for the children going to and from schools. Jay walkers and pedestrians going against traffic are arrested. Passenger safety zones protected by traffic buttons give the necessary protection to street car traffic.

Detroit claims the distinction of having the densest traffic points in the country, a condition formerly found in New York. An official report shows that traffic in Detroit at Grand River and Grand Boulevard west is in excess of what it was at the last count made at Forty-second St. and Fifth Ave., New York. Traffic at Jefferson Ave. east and St. Antoine St. exceeds the traffic at the famous New York intersection by 18 per cent. The 15 heaviest traffic streets in Detroit carry at the center 4 per cent more than the 15 heaviest traffic streets in New York.

Detroit is undertaking the solution of this problem through the establishment

of a complete system of super-highways encircling the city and providing optional routes into, through and around the congested areas. In general the layout provides for rights-of-way 204 ft. in width, improved with two 40-ft. pavements separated by a car track space. On the two paved areas traffic lanes are established to segregate the fast through traffic from the slower heavy or local traffic. Intersecting streets and approaches to the car tracks will pass under the lanes of fast traffic and regulated speeding will be encouraged. The development has reached a stage in Woodward Avenue that is attracting the attention of traffic officials and city planners from many communities.

Arthur S. Tuttle, Chief Engineer of the Board of Estimate and Apportionment of the City of New York, speaking on City Planning as a Permanent Solution of the Traffic Problem, is quoted as follows:

".. .. .. It was not until about 1903 that the inadequacy of our present streets began to be realized, and since this date there has been a continuous progressive movement in the direction of improving conditions at points of congestion.

.. .. .. With a view of ascertaining the sense of the community and more particularly the views of the various organizations which have made the problem one of great concern, a public hearing was given by committee in New York a short time ago for the purpose of collating all of the suggestions which might be offered as an aid in its investigation, at which time, however, practically no suggestions of value which could be construed as strictly novel were offered, although most of those which have heretofore been under consideration were placed in evidence, these comprising the following:

1. The systematic control of street traffic, both vehicular and pedestrian, in which connection an effort should be made to bring about uniformity in traffic signs and signals throughout the country, with sufficient variation in control to meet the requirements of local situations.

2. The improvement of existing streets through the removal of obstructions, the laying of smooth pavements, the widening of roadways where practicable without undue encroachment upon the sidewalks, and the provision of easy curves at the intersections.

3. The introduction of by-passes to enable through traffic to avoid congested centers.

4. The limitation of the dimensions and weights of different types of vehicles.

5. The fixing of roadway widths to conform with the types of vehicles which they are likely to be called upon to accommodate.

6. The separation of grades at street intersections at points where this can be effected without undue property damage.

7. The construction of elevated express streets along the waterfront or where they can be introduced without undue deprivation of light and air or interference with surface traffic.

8. The provision of adequate parking accommodation for automobiles in or near the congested business and commercial centers, this being accomplished either by setting aside public areas for this purpose or through the construction, either municipally or privately, of parking garages.

9. The placing of the burden of providing parking and loading spaces at least in part upon the property owners.

10. The widening of existing streets, where practicable, or accomplishing a similar result by the introduction of sidewalk arcades with a corresponding widening of the roadway.

11. The cutting through of new arterial streets where additional facilities can be obtained by no other method.

12. The control of density of traffic by imposing additional restrictions on heights of buildings.

13. Lowering the peak of vehicular traffic by compulsory night trucking.

14. The substitution, where practicable, of buses for surface railroads, and the removal of abandoned surface tracks.

15. The construction of underground rail facilities for the delivery of store freight.

16. The provision of undercrossings for pedestrians at the busy traffic points, preferably in connection with the operation of underground rapid transit systems.

17. The setting up of more liberal standards for the width of both local and arterial streets in the planning of new territory, or the assignment of a greater proportion of the city area to street purposes.

18. The acquisition of court yard areas during early stages of development

which can be thrown into the street system when and as required."

Many of the suggestions offered in this list have been applied to the traffic problems of other communities and many of them are not at all applicable to your local problem or to the traffic problem of Gary. In studying our local problems we find that we must work out our own salvation—and it is usually undertaken with fear and trembling. When we can find a similar problem satisfactorily solved in some other community we gratefully accept it as a guide for our endeavors. When we find that some other community has solved one of their problems in a similar manner to our solution we feel that they must surely be a wide awake and exceedingly progressive group.

To accomplish an entrance to the newly acquired park in the Dunes will require some solution to a traffic problem that at present is quite effective as a barrier to the Dunes on a good day in summer. The Dunes Highway is so overloaded with traffic on Sundays and holidays that drivers have spent from four to five hours traveling on concrete pavement the distance of 25 miles from Michigan City to Gary.

The Chicago City Council has effected the creation of a street traffic commission to make an analysis of traffic problems for a year and then to formulate a comprehensive traffic plan and uniform traffic code for the Chicago Metropolitan area. The commission is to be made up of aldermen, city officials and the street traffic committee of the Chicago Association of Commerce which proposes to furnish $50,000 for the first year's survey operations.

Already they have developed some rather startling data in reference to truck traffic. On the highways leading into Chicago the truck traffic is not 25% to 40% as the average driver supposes but less than 7% as shown by traffic count. The maximum truck traffic is on Indianapolis Avenue where in the count of 12,635 motor vehicles, 782 or 6.2% were trucks. The average on all roads is probably about 4%. On a study of truck traffic it was found that about 96½% of total truck mileage is on city streets.

The fact that Gary is in the district being studied by the Chicago Regional Planning Conference and is co-operating in this study is offered as an explanation for the use of so many examples from Chicago.

When we find, as we found last summer, that approximately 1,000 cars per hour were passing through our city with no desire to stop, we set about making it easier for them and safer for our citizens. We opened up and widened a route that became available as a by-pass to separate this through traffic from our local traffic.

When we found that our main down town street was becoming inadequate because of rough pavement, poor car track construction, and unlimited parking, we remedied the situation by paving the entire width with smooth pavement, limiting parking to one hour, removed the raised cross walks, increased the radius at intersections and have as a final step removed the center poles that have been supporting the trolley lines on brackets. This final step has accomplished the mental effect of increasing the width of the pavement about six feet.

There are many other items that enter into the traffic problem. Congestion of traffic at railway grade crossings on busy streets may be eliminated through grade separation and many of our Indiana cities are proceeding to remove this obstruction both as an obstruction and as a hazard.

The installation of traffic signals, if given the proper preliminary study, will certainly assist in regulating and directing traffic. It has been our experience in Gary that our signals are best adopted to serve the needs of the community when they are of the same type as in use in Chicago. This but emphasizes the need for uniformity in signals.

In some cities one-way traffic on some streets solves the problem but we have not found this true in Gary. Chief Collins of Chicago stated recently at the American Road Builders' Association meeting that Chicago could not operate on one-way traffic streets.

Gary tried out a restriction against left turns at several busy intersections and received such protest from the business men in all directions from the several intersections that the rule was abolished.

BITUMINOUS MACADAM AND SURFACE TREATMENT ROAD WORK IN INDIANA

By Earl B. Lockridge, District Engineer, Indiana State Highway Commission.

(A paper read at the 1926 Purdue Road School.)

Bituminous macadam, also known as penetration macadam because of its type

of construction, is probably done an injustice more frequently than most any other type of pavement through inferior construction, attempts to construct too cheaply, and the salvaging of old gravel and stone surfaces that are not worthy of the consideration given them.

The quantity and quality of material that combines to make this pavement is of the utmost importance, yet no less important is the skill and judgment of workmen who assemble, rake, spread, penetrate, roll and mould these ingredients into the final compact surface. Weather conditions are a factor and must always be taken into account, low temperatures and dampness being especially objectionable. Unlike some types of pavement wherein costly mechanical appliances have been provided, which, if operated by honest hands, will do uniformly good work, the degree of refinement and perfection of a bituminous macadam job depends to a large extent upon the skill of workmen and the knowledge and alertness of the inspector in charge.

It is well to surface-treat a bituminous macadam pavement the first and probably the second year after construction, and thereafter as surface conditions require. Original construction and surface treatment may be of either tar or asphalt. The lighter tar being more pliable, has been found to be quite practical for the first treatment after construction. It may be gone over with the ordinary drag such as is used in stone and gravel road maintenance. The drag carries surplus material (tar and stone chips) to the low places, also helping to eliminate the mechanical defects if any exist. The asphalt treatment will ordinarily wear longer and not need to be repeated so often. Those roads of which I have had personal observation, have had treatments ranging from a third of a gallon of bituminous material per square yard of surface, when first taken over by the state in bad condition, to as low as one sixth of a gallon per square yard of surface when found in good condition, treatments coming about every other year.

Before applying bituminous material, the surface to be treated must be thoroughly cleaned and dry. Traffic should be kept off, both for its own protection and the good of the work, until after covering material has been added. If possible the road should be closed for one or two days, though in actual practice, I suspect there are more cases where traffic is merely warned of fresh bituminous materials than there are where the road being treated is really closed. The bituminous material should be uniformly applied at proper temperature from an approved pressure distributor.

It is essential that the covering material be applied without delay after a surface has been treated, said covering to consist of stone, slag or gravel, thoroughly clean and graded closely between one-quarter and three-quarter inch in size. An excess of the larger size is preferable when treating an open, comparatively rough surface, while the smaller size is desirable when you have a surface that is well closed and smooth. The quantity of covering material to be used per square yard of surface depends upon the condition of the surface, the grade of tar or asphalt being applied, and the amount of same that is applied per square yard of surface. For estimate purposes, where tar is used, it might be said that 54 lbs. of stone to the gallon or 1 cu. yd. to 46 gals. and where asphalt is used 88 lbs. of stone to the gallon or 1 cu. yd. to 28 gals. of the bituminous material is about right. The same gallonage would prevail per cubic yard for slag or gravel. The covering material should always be spread direct from dump trucks as they will spread it more uniformly and cheaper than can possibly be done by hand from piles or conveyance not equipped with dump. A bituminous macadam pavement properly constructed will improve under traffic and maintenance, riding smoother year after year.

Lincoln Highway

It has been my lot to have charge of the Lincoln Highway through Porter and LaPort Counties where the State Highway Commission through its maintenance department has reconstructed the entire section of 21 miles between the cities of Valparaiso and LaPorte. Within this distance there were many vexing, if not contemptible things to handle, not the least of which was the matter of securing sufficient right-of-way on which to construct and operate a creditable pavement. There were drainage pipes and small concrete culverts to extend, new alignments requiring fills of half or entire width of roadbed, narrow grades to be widened, and worst of all a satisfactory base course to be prepared on which to place the bituminous top. Parts of the original road had been well constructed as a waterbound macadam pavement

(though with excess crown) to the width of 10 and 12 ft. and later surface treated, then parts were allowed to lapse into an ordinary stone road through failure to follow up with subsequent treatments. Other parts of this road consisted of a conglomeration of stone, slag, gravel, and cinders varying in width, depth, and quality of material until it was difficult to know just what additional new material should be added in preparing suitable base without being extravagant. The outer 3 ft. on either side of an 18-ft. strip had to be built up throughout and a light waterbound course was necessary over the entire top, in most cases, to reduce the crown of the old surface when not required to give additional strength of base. At a few points it was found necessary to alter grade because of abrupt changes, but in the main every bit of the old road was salvaged and stands today as a part of the new construction, the taxpayer still realizing from the original investment in roadbed, stone, and drainage structures. This is the feature that should appeal to the taxpayer in this type of construction—nothing is wasted or destroyed that already exists.

Maintenance

Having misjudged strength of base or through other causes having secured faulty pavement, the matter of maintenance or repair becomes a more difficult problem. If the pavement breaks near the edges it indicates a weak base, poorly compacted fill in widening the roadbed, or lack of rolling or perhaps insufficient drainage. There may be a spot that shows signs of raveling or rutting due to insufficient bituminous material or failure to penetrate because of dirty surface closed too tightly or saturated with water. Whatever the cause may be it is well that those who have in charge the matter of making repairs should at first attempt to diagnose the case and then proceed to remedy both defect and cause in an intelligent manner, using one of the several grades of tar or asphalt best adapted to the character of repairs to be made.

Bituminous macadam surfaces can always be patched without seriously interfering with traffic. Patches are made of premixed cold or heated materials, or by penetration method if of sufficient size to warrant same and may be either hand tamped or rolled into place. More frequently the cold mix materials are used (tar T.C.M. or emulsified asphalt) and the patches being small and far apart, are compacted with hand tamp. The refinement to be attained in patching or eliminating construction defects, is entirely within the hands of those performing the task. A skilled man with mechanical eye will feather-edge his work until you cannot tell where the patch is except by color and not at all after the next surface treatment has been applied.

The size of aggregate to be used should vary with the depth of patch or repairs that are being made. A deep patch might be made with all fine aggregate, but it would be more practical if the coarser sizes of stone were used, and with the thin layer to be feather-edged it is obvious that the smaller aggregate will have to be used. There is a small amount of settlement due to the mixed material compacting under tamp, and under later traffic, varying with the depth. That feature is readily mastered by the observing workman who can make proper allowance.

Where it becomes necessary to make repairs because of raveling or desire to eliminate a low spot due to faulty construction, the hole or surface is thoroughly swept and cleaned of all loose or foreign matter and painted lightly with the bituminous material of which the patch is being made. This insures bonding and helps to seal against moisture getting under the patch. Likewise the top should be sealed and made more dense by brushing a thin coat of the bituminous material over it and applying some fine stone or coarse sand. It is very necessary to have a dry surface and dry aggregate when using any of the bituminous repair materials except emulsified asphalt. This material may be used on a damp surface with damp aggregate, the only difference being that you mix less water with the emulsified asphalt under those conditions.

Surface Treatment

Surface treatment road work consists of two distinct types, that following the construction of a bituminous macadam pavement and that wherein the first bituminous material used consists of a treatment direct to the surface of a waterbound macadam, stone or gravel road. A well constructed waterbound macadam road that is not burdened with excessive traffic can be treated, made dustless, less costly in maintenance and frequently pass as a bituminous macadam job at a very low cost. If, when constructing the waterbound macadam road, it is known that a bituminous treatment is to be

given, it is well to reduce the quantity of the screenings so as to leave the top stone exposed, making it possible for the bituminous material to adhere to more of the surface of this coarse aggregate. A waterbound surface must be thoroughly swept and cleaned of all foreign matter before treatment. The surface must be dry and the temperature of the atmosphere above 45 degrees Fahrenheit. The temperature of the bituminous material to be as specified for the grade used and to be uniformly applied from an approved type of pressure distributor. Ordinarily on this type of surface treatment work, the gallonage per square yard of surface is much greater than used on bituminous macadam maintenance, necessitating two or more applications. It should never be applied at such rate as will permit of bituminous material running off the edges of the metal and wasting.

The same principles involved in treating bituminous macadam and waterbound macadam also prevail in the treatment of stone and gravel surfaces. Under proper conditions, the first application of say three-tenths of a gallon per square yard will penetrate until it entirely disappears from the surface. After this treatment has been given sufficient time (perhaps 24 hours) in which to penetrate and get set, additional treatment or treatments follow until the required amount of bituminous material has been applied. Then the surface is covered with fine stone, slag, or gravel, the quantity depending upon condition of surface and amount of excess bituminous material that remains to be absorbed. It may be necessary to give a very light application of covering material after each application of bituminous material, to prevent flowing to the edges in case of smooth surface and excess crown, also to prevent picking up on distributor wheels when making the next application. After the last application and all covering material is in place, the surface should be dragged repeatedly until every chip or pebble is thoroughly coated and the surface becomes tacky. Traffic should be kept from the surface throughout the process of treatment and for about two days after dragging operations have ceased, during which time a curing effect takes place, leaving a dry dustless surface that will stand up under quite heavy traffic. This is very cheap and practical maintenance when properly carried out under favorable conditions, though I fear it is too often tried as an experiment under adverse conditions, thereby resulting in the abominable pot holes and abrupt breaks in the surface such as we frequently find on heavy traveled streets through the smaller towns where an attempt has been made to eliminate the dust, regardless of the kind of surface to be treated, the grade of material to be used or the correct manner of applying.

SEWAGE WORKS DESIGN AT CHICAGO

By L. C. Whittemore, Assistant Sanitary Engineer, The Sanitary District of Chicago.

(Editor's Note: The following paper was read before the Western Society of Engineers at Chicago on Feb. 1, 1926.)

The design of sewage treatment works, as related to the work of the Sanitary District of Chicago, involves two distinct problems: first, that of providing for some of the very small communities of 1,000 to 1,500 people within the district, too far distant from the main centers of populations to make delivery of their sewage to the larger treatment plants economically feasible; and second, the larger plants, varying in population loading from a minimum of about 15,000 up to the West Side Plant, now being designed for a tributary population of 1,850,000.

Plants of the first type are designed for automatic operation and for a minimum of attention and control. For this reason, Imhoff tanks followed by trickling filters are always preferred to activated sludge, as our experience has clearly indicated that successful results can be obtained with the latter method only by constant and skilled supervision. Among the more novel features employed in the later designs for plants of this type are the use of creosoted timber construction in place of the more expensive concrete for the interior baffles and gas vents, and the use of high parapet walls around the trickling filters to conceal the spray from view and prevent its dissemination by the wind. Although of small size, great care is used in the design of these plants to guard against possible interruptions in operation.

As the sewerage treatment program ahead of the District eventually points to a more or less complete treatment of all sewage, studies for the larger plants are in general, confined to a comparison of activated sludge versus sedimentation in

Imhoff tanks followed either by trickling filters or by activated sludge. Consideration will be given to a few of the more important points involved in the design of the largest plants of these two types, as represented by the North and West Side plants respectively.

Grit chambers are provided for all of the larger plants of both types and for those of first magnitude, the chambers are to be covered so that removal of the grit may be conveniently carried on at all seasons of the year. Where facilities are not available for disposing of the grit on the plant site, grit washers are to be provided to wash out any organic matter that may deposit and render the grit inoffensive for shipment.

Inasmuch as the cost of power for compressing the air is one of the chief elements in the operating charges for plants of the activated sludge type, a great deal of study has been given to methods for reducing the use of air. To this end, preliminary settling of the raw sewage for about 30 minutes has been substituted for fine screenings, as originally contemplated for the North Side plant. It is believed that the increased removal of coarse solids will result in a material saving in the use of air. Incidentally opportunity is afforded in the same tanks for partial removal of grease and oils by skimming. This scheme might not be applicable, however, where the waste sludge is to be dewatered and prepared as a fertilizer base. The aeration tanks are of the circulating type with diffuser plates arranged in longitudinal rows along one side of the tanks. Experiment has shown that somewhat less air is required with this arrangement than with the ridge and furrow construction.

In the design of the main settling tanks, we have endeavored to secure proper distribution of flow and to avoid dead spaces, by admitting the influent over long weirs, properly spaced and made adjustable in height for equalizing the flow to the various units.

The settled sludge will be swept to the draw-off pipes at the tank centers by clarifiers of the Dorr type. For the North Side plant, these mechanisms have been made with pivoted and counterweighted extension arms, making it possible to sweep to the corners of tanks substantially square in section. This permits economy and simplicity in construction, as compared with the circular or octagonal tanks required with mechanisms of the fixed arm type, and also makes possible a more efficent use of the tank as a settling device by eliminating the dead corners.

Owing to the relatively delicate control required for successful operation of the activated sludge process, very complete metering equipment is considered essential. Each aeration unit is provided with sewage and air flow meters. The return sludge to each battery of tanks is also metered. The flow of waste sludge is to be controlled by the use of rate controllers similar to those used in water filtration practice. The waste sludge from the North Side plant is to be pumped to the west of the city and disposed of by digestion in the Imhoff tanks at the West Side Plant.

In the design of plants of the Imhoff type, increasing attention is being paid to the preliminary treatment of the sewage. In addition to grit removal, provision may be needed for easy removal of floating material in the largest plants at least. This may be done by skimming in the flowing-through chambers and gas vents or by preliminary treatment in tanks designed to operate as skimming basins. If the latter be used, the bottom sludge will be discharged into the digestion compartments of the Imhoff tanks for further treatment.

The tank units for the large west side plant will have only two hoppers in series, each 40 ft. square, in place, of the three or more now commonly used, and the dividing walls between adjacent pairs will be omitted making each unit 80 ft. square and effecting a considerable economy in construction.

In a plant of this size, involving an initial installation of somewhat over 100 units, the problem of securing uniform distribution of the sewage and its contained solids, becomes one of paramount importance. As a partial aid, the plant is divided into three batteries, each controlled by a master meter. To secure equal distribution to individual units, the use of submerged orifices of varying size with weirs set to maintain a constant elevation in the tanks is contemplated. The orifices will be located in the influent channels so as to draw sewage of average suspended-solid content as far as possible. Simplification in reversing the flow through the tanks is being sought by controlling the operation by shifting the main gates feeding large groups of units instead of by opening and closing gates on the inlets and outlets

to the individual settling compartments —several hundred in number. Visual inspection of the sludge as it is withdrawn from individual hoppers is provided for, and scum outlets from the gas vents will be installed. Studies for collecting the gas from the gas vents are also being made, as the possibility of recovering a valuable by-product, with comparatively little expense for equipment, appears to be quite favorable. Removal of the sludge from the drying beds in a plant of this size is one of considerable magnitude, involving the handling of upwards of 2,000 cu. yds. of material daily during the drying season. The development of a mechanical cleaning device is therefore being attempted.

The layout for the west side plant, where Imhoff tanks only are to be installed for the present, is being so arranged that trickling filters or activated sludge units may be added whenever complete treatment becomes necessary.

PLANS FOR 1927 ROAD SHOW

Announcement is made by the American Road Builders' Association that the 1927 Convention and Road Show will be held in Chicago during Good Roads Week, January 10-14 inclusive. From every indication it is easy to predict that this convention will eclipse all previous ones.

The road show will be held in the Coliseum as usual but the convention and headquarters this year will be at the New Palmer House where larger rooms are available for the meetings and banquet. Official headquarters will be opened December 10, 1926.

Mr. H. G. Shirley, president of the association and chairman of the Virginia Highway Commission, has arranged a program consisting of two sections—one arranged for engineers and officials and the other for contractors, manufacturers and material producers.

The chairman of the program committee is Mr. H. K. Bishop, of the Bureau of Public Roads, and he has assisting him, Mr. S. M. Williams of the Autocar Company, in charge of the contractors' program; and Mr Paul Tebbs of the Pennsylvania State Highway Department in charge of the engineers' program.

The preliminary plans have already been completed and a program is promised that will prove both interesting and valuable in the economic construction, maintenance and operation of highways.

Already the applications for space have exceeded that of last year when approximately 300 carloads of the latest improved road building machinery and materials were on exhibition.

Many exhibitors have displayed their new improvements at the road show for years but this year the applications show that an exceptionally large amount of new developments and improvements will be shown, a fact most interesting to the engineer, official and contractor.

Many new features will mark the 1927 convention and road show. Tuesday, January 11, will be designated as "Governors' Day". All state governors will be invited and many ex-governors—especially those that have been identified with the "Good Roads Movement".

President Shirley and the association directors will entertain the visiting governors at a good roads governors' banquet on the evening of Governors' Day. The chairman of the Governors' Day committee is Mr. Fred Reimer, consulting engineer, East Orange, N. J.

January 12th will be "Pan-American Day". All countries in North, Central and South America will be invited to send delegates and have exhibits. On "Pan-American Day" a portion of the program will be presented by delegates from Pan-American countries, setting forth the road situation in those countries. Last year with no special arrangements being made for Pan-American delegates seven different countries were represented.

The Pan-American Day committee will be headed by Col. R. Keith Compton, director, department of public works, Richmond, Virginia. One of the features will be a banquet given by the president and directors to the appointed delegates.

Again the entertainment committee will be headed by Mr. Arch Cronkrite, of the Universal Portland Cement Co. Those that have attended the conventions in the past few years have known that the few hours between sessions, and in the evenings, have been provided with high class entertainment of a variety that was truly appreciated by road builders.

The road builders banquet has grown into one of the important functions of the convention. Last year it was necessary to limit the number to 1,200, and a number of people were deprived the pleasure of hearing Mr. Charles Schwab make his excellent address.

This year ample provision has been

made for 2,000 road builders. Mr. Paul Griffith, of the American Tar Products Company, Pittsburgh, Pa., is again to head the banquet committee and he and President Shirley are now making arrangements with a nationally known speaker who is sure to interest everyone present.

Although the hotel conditions in Chicago last year were a great improvement over previous years, the convention buruea of Chicago has promised still greater improvement. Mr. William J. Hennesy of the Bureau of Conventions of Chicago, will again act as chairman of the hotel committee.

Reservation booklets showing the name and location of all hotels; and blanks for the purpose of making reservations may be obtained from all exhibitors and will be furnished to all those that registered last year.

The Coliseum committee will be headed by Mr. J. E. Tate, of the Portland Cement Association, and his presence will assure the proper handling of all details at the Coliseum.

The press committee, which functions throughout the year, is in charge of Mr. R. M. Arundel.

Registration this year will be in charge of Mr. William Ogden, of the Lakewood Engineering Company, Cleveland, O. He will be prepared to handle 35,000 people in the four days of the convention.

Reduced railroad fares will be granted to all members of the American Road Builders' Association and their families. Previously the railroads had granted reduced fares to all delegates but this year it is granted only to members. Detailed methods of securing reduced fares will be furnished all exhibitors and those that registered last year.

The Bureau of Public Roads has planned a novel exhibit, both interesting and educational, for the Coliseum, and also for the Palmer House, adjacent to the convention meeting rooms. In this location at the Palmer House the association of state highway officials, highway research board, several state highway departments—and some of the Pan-American countries will also have exhibits. Several technical associations will be invited to exhibit at this technical and educational exhibit.

In order to increase the interest for which the association stands, among those connected with road building, the association is offering a free trip to the convention and road show with all expenses paid. It is open to all engineers and inspectors, exclusive of state highway engineers, connected with road work in any city, county or state. The subject is to be a 1,500-word description of a machine, material or methods used in the construction, maintenance or operation of roads or pavements.

With the advantages of an exposition of the latest improved road building machines and a convention presenting the latest methods, all of which can be attended in four days, it is hoped that the several states, counties and cities will send many delegates in order that they may keep pace with the latest methods which are shown at this, the greatest exposition of its kind in the world.

Detailed or additional information may be had from the Business Director, Charles M. Upham, Raleigh, N. C.

COORDINATING RAILWAY AND HIGHWAY TRANSPORTATION

By Frank H. Alfred, President Pere Marquette R. R., Detroit, Mich.

(From a paper read at the 1926 meeting of the American Road Builders Association.)

We speak of the great loss of life and money brought on by the World War as a useless waste. The great conflict, however, is responsible, in a large measure, for the greatest growth and development that this country has ever known, and possibly will ever experience again. Road building was directly stimulated by government agencies. The authorities were concerned with the condition of our highways and the impossibility of using them as arteries for the movement of war materials; they set about, through legislation, to make possible the development of permanent roads linking up the large industrial centers. Laws were passed by which the federal government joined with the states and with the local communities in supplying the necessary funds.

To my mind, the greater part of the direct benefit from the recent extension of our highway system accrues to the farmer. Transportation of his produce to market is greatly facilitated. A farmer living five miles from town could haul two loads of corn per day, perhaps 60 or 80 bushels in all. With a truck and improved roads, he can, in the same time, easily haul 200 bushels. Further, he is able to move his crops to market so

quickly that he can take advantage of favorable prices, which was not always possible under former conditions.

Price of land adjacent to improved highways has been increased to two, three and even ten times its former value. This increase is particularly marked in the vicinity of cities, where the improved highways have greatly stimulated suburban development.

In addition to these financial benefits, the improved highways bring the country dweller closer to his neighbors, and make available to him the recreational and cultural advantages of the town. A resident of the country has, in effect, become a member of the urban community. Any small town on Saturday night is a demonstration of this fact. The average standard of living of the rural population has been appreciably raised. The farmer has more requirements and consumes more and different commodities than formerly, which results in increased production on the part of others to supply his requirements. With this has come more leisure in which to avail himself of his new advantages.

Improved highways give the city dweller an opportunity to go out into the open country to enjoy its fresh air and natural beauty. His financial benefit is for the most part indirect, and arises from the stimulus to industry due to the farmers' increased consumption.

The railroads are also largely benefited by better roads. Modern highways are supplementing the railroads by bringing them within easy access of communities that are 10, 20 or even 50 miles distant. Railroads are further benefited by the increased traffic which results from highway improvement due to, first, hauling the material for constructing the roads, and second to that which is much more important and lasting, namely, hauling the commodities produced under the stimulus above referred to. They also benefit from the desire to travel, which the automobile in connection with improved highways has brought to our people.

Our good roads have been built at the demand of the private users, but buses and trucks engaged in commercial transportation have been quick to grasp the advantages which they offer. As a result, pavements are made heavier than formerly, and heavier than would be necessary were it not for such use.

Although the traffic handled by the railroad and by the highway for the most part differs in its nature, they are competitors to a certain extent. The railroads can scarcely expect to retrieve the passenger traffic lost on account of the use of privately owned automobiles; nor can they hope to compete with buses in the field of short hauls and frequent service, as the large investment and high cost of operation required for railroads to give as frequent service as the buses makes it out of the question. On longer hauls, the railroads offer more comfort, greater safety and dispatch. In addition, they handle passengers' baggage free of charge, a fact too often lost sight of in comparing the service rendered.

Freight competition is practically restricted to less than carload freight having a comparatively short haul. To the casual observer this might appear to be an important part of a railroad's traffic, as it is conspicuous and he sees but little of the tremendous volume which moves in carload lots. As a matter of fact, the tons of less than carload freight handled on the Pere Marquette in 1924 was less than 2½% of the total. A large share of this 2½% had a long haul not suited to highway transportation, so that probably the freight traffic which is actually competitive amounts to not more than 1%. Further, this is probably the least profitable portion of the railroads' freight traffic as the expense of handling it is so high, including as it does the use of facilities in central locations where the property has an extremely high value.

The other day a neighbor of mine moved to Orange, New Jersey. His household goods were locked into a van at Detroit, and were unloaded at his new home in Orange. It was not necessary to crate for packing as if for shipment by rail, and I was told that the total cost of handling the goods in this way was little, if any, more than it would have been to ship by rail, and of course the movement from house to house was quicker. The shipment of household goods by truck has advantages peculiar to that class of freight, chief among which is the fact that it is not necessary to do any crating—the most expensive part of moving. The shipment of household goods by rail is in its nature extra hazardous and, therefore, bears a high rate. Further, in this particular case, the rate at which these goods were moved by truck was made possible by having a return load, a condition which can only exist between large centers of population.

The railroads cannot reasonably object to any loss of traffic to highways, waterways or other form of transportation, where such transportation is more economical than that afforded by the railroads. In fact such objection would be quite futile, for just as surely as water seeks its level, so will the best method of transporting all classes of business be eventually reached. The railroads may object, with reason however, if competing transportation facilities are aided either by direct subsidy, by being granted free use of public improvements, by being relieved of taxation, or by being absolved from regulatory restrictions which must be borne by the railroads. As matters now stand, the railroads are regulated as to rates which they may charge, as to their dealings with their employes and the public, and in many other ways. They are heavily taxed, and a very considerable share of taxes which they pay is expended in the improvement of highways, to which they raise no objection. Commercial highway transportation, both passenger and freight, is not subject to regulation. Further, their right of way and roadbed is provided and maintained by the public, and they pay taxes only on the same basis as other users of the highway. Without raising here the question as to whether or not such virtual subsidy of commercial highway transport is the best public policy, it may be stated that from a railroad man's point of view it does not seem quite fair, especially when the relative value of the service rendered the community by the two forms of transportation is taken into account. The absence of supervision of highway transport by a regulatory body is to be deplored. Irresponsible parties enter the business and operate for a time at less than cost, to their own ultimate financial ruin, and to the detriment of legitimate carriers. In such cases, the passenger or shipper has small chance of collecting damages in case of loss or personal injury. These features are not in the public interest, and no doubt will be corrected in the course of time.

There is little doubt that the public would be best served by a system of transportation which included under one management, railway and highway transportation—in other words, by the absorption by the railroads of the companies engaged in commercial transportation on the highways. At the present time such an arrangement does not appear generally feasible, on account of various obstacles, legal and otherwise.

Under present circumstances, the most satisfactory results can be obtained by each form of transportation co-operating with the other to the fullest extent possible, each profiting by the other's experience, and aiding, so far as it may without injury to itself, the other's development in the field to which it is best adapted. The present trend seems to be in this direction.

I offer no definite program of coordination under present conditions. The important thing at this time is for those engaged in railroad and in highway transportation to realize that their legitimate and profitable fields do not overlap to any considerable extent, and that each has more to gain by working with the other than by opposing him. This spirit will lead to co-operation, and perhaps ultimately to combination.

But co-operation must be based on an equitable distribution of burden, responsibility and reward. The railroads must learn to give up, with good grace, that part of their business which can be handled with more economy on the highways. On the other hand, those engaged in commercial transportation on the highways must not object to paying a just and fair amount to the public for their use. Such use requires a more expensive highway than would otherwise be needed, and in general the taxes paid on commercial vehicles are not commensurate either with the cost and inconveniences of such use to the public or its value to the user. Neither must they object to being subjected to such regulation and restriction as may prove to be in the interest of the public.

The railways must maintain their independence, and in doing so, acknowledge their interdependence.

A promising field for co-operation of railroad and motor truck transportation is the handling of less than carload business in large cities. The delivery of such freight by railroad to an outlying freight house, and its transfer there to trucks for delivery seems quite feasible. These trucks would deliver either to small distributing warehouses located in various parts of the city, or direct to the consignee, and would handle freight for shipment in the same manner. The expensive and frequently unsightly downtown freight houses would thus be done away with and the sites which they occupy be used for other purposes.

In their development of a type of pavement which is perfectly adapted to their present requirements, the highways offer a valuable lesson to the railroads. About eight years ago, before our highways were subject to the heavy truck traffic and speed that they now are, the property owners of the community where I own a farm were called together to consider the building of a road. When the question of what kind of road to build came up, I took the position that a first class gravel road was all that was required, and that it would be an extravagance to undertake to build a concrete road, feeling that a gravel road well built and maintained would answer every purpose. Fortunately, in spite of my objection, it was decided to build a concrete road according to plans and specifications which have been generally followed in the building of the main trunk highways throughout the country, laying grade lines that provide for generous embankments and heavy cuttings, thus getting entirely away from the surface construction that had previously been in general use.

I have watched development of highway building, and have come to the conclusion that it is almost impossible to prevent cupping or corrugation from taking place on gravel highways where a speed of 30 miles an hour or over is permitted. This cupping is due to the same conditions that cause low joints on a railroad, and unless it be given immediate attention, which it is almost impossible to do, the roadbed is soon filled with a series of depressions which are annoying and costly. Many experiments are of record as to the cost of operating over highways of different construction. The saving in the use of concrete over gravel on heavy traffic roads is very great. There is the saving in maintenance, which accrues to the state or municipality responsible for the road's upkeep, and there is a greater saving to the users of the road due to reduced tractive effort. A gravel road requires continuous maintenance, which under heavy traffic is expensive. Plymouth Road, one of the main thoroughfares leading out of Detroit, was paved with concrete about a year ago, replacing gravel. For three pears prior to this replacement the average annual cost per mile of maintaing the surface of this gravel road was $1,290. The average cost of maintaining the surface of concrete roads in Wayne County is about $250 per mile. In addition to the high cost of maintaining gravel roads, the discomfort and dust are serious disadvantages.

The railroads are now in the gravel stage. Millions upon millions of dollars are expended annually on what might be termed waste, as it does not result in a permanent improvement in the condition of the track. Track labor consists largely of a continuous process of relining and resurfacing track and picking up low joints.

My impression is that the present style of roadbed, which has been in use almost ever since railroading began, must give way to a more modern form of track construction. Ballast, ties, and the pesent form of rail attachments must be superseded by something more permanent, and the economic waste in connection with maintenance largely reduced.

Railroads have made a wonderful record in the last few years in reducing the cost of transportation, and their properties are in better shape now than they have ever been, but we are not proprogressing as rapidly as we should to retain supremacy.

The great wealth of this country is made possible by its builders. Every man should build something for himself. It identifies him with our national life. I have always recommended to every young man who has a bent in that direction, to take up the study of engineering or architecture, and thus fit himself for a part in the great onward movement of our nation. I would not influence any young man whose inclination is along other channels. We have need for men of all professions and callings. The chemist, the astronomer, the geologist, the lawyer to keep us from entanglements, and the doctor to keep the busy builder fit for his task.

Do not overlook the expressions of art that should be reflected in some way in every piece of construction. Engineers in making designs for work should not overlook the aesthetic features. Each of us, in order to be successful, must be fascinated with our own work, whether it be the most menial kind of labor or achievement of the highest order. All who achieve are builders in a sense, "some of massive deeds and great, and some of ornaments of rhyme".

SOUTH CAROLINA TESTS ON REINFORCED CONCRETE PIPE

By A. E. Warren, Testing Engineer, South Carolina State Highway Department.

In 1923 the South Carolina State Highway Department began the extensive use of reinforced concrete pipe for pipe culverts. The state has a considerable mileage of roads so located that their drainage structures are subject to salt water tide action. Rumors of failures of reinforced concrete pipe used in or near sea water by cities along the coast began to reach the department. Authentic information on the subject was scarce, and in order to secure some first-hand data this series of tests was started, using pipe and materials of known quality, so placed in sea water that individual points could be removed occasionally for examination and tests.

The tests were started in May, 1924. The first pipe selected for test consisted of 20 joints of 18-in. reinforced concrete pipe, made by the "hand poured" method as contrasted to the machine made. This pipe was placed in the ocean at Charleston, S. C., on July 1, 1924, midway between high and low tide. The tide at this point averages about 6 ft.

The 1924 specifications did not require the pipe to pass a hydrostatic test. A simple hydrostatic test was, however, made on the pipe by sealing one end of a joint, standing the joint on the sealed end, and counting the leaks that appeared on the outer wall within ten minutes after the pipe was filled with water.

When tested in this manner the 18-in. pipe made for the sea water test in 1924 had an average of about 20 leaks to a joint 3 ft. long. The leaks appeared mostly in circular rings about the pipe, following the lines of the reinforcing wires.

It appeared probable that concrete that would permit the passage of water through the pipe walls in this manner would not provide protection for the reinforcing steel against the corroding elements of salt water and air. A series of tests was then made to find the best manner of reducing the number of leaks that appeared in the hydrostatic test. The steps taken included the use of admixtures of Celite and hydrated lime; the use of smaller size coarse aggregate; the use of additional cement and variations in the consistency and manner of tamping.

The department was purchasing concrete pipe from four different manufacturers in 1924. In order to see if "leaky" pipe was typical, hydrostatic tests were made on the 18-in. pipe at all four plants. Pipe from two of the plants showed an average of 20 leaks to a 3-ft. joint; pipe from the third plant showed an average of six leaks to a joint; and pipe from a fourth plant an average of two leaks to a joint. The plants which were apparently being the most careful furnished pipe with the greatest number of leaks, the leaks being due largely to the use of a comparatively dry mix for where a sloppy mix was used the number of leaks was greatly reduced, and the strength of the pipe also was reduced due to the use of excess water. The leaks appeared only in pipe of 18 ins. or less diameter, the thicker wall used for the larger size pipe being sufficient to prevent leakage. In July, 1925, 18 joints of 18-in. diameter machine-made reinforced concrete pipe were also placed in the ocean at the side of the hand-poured pipe placed in 1924. The results showed a rather high absorption, 8.3 per cent, which was mostly due to the very dry mix used. This mix was so dry that water marks did not appear on the surface of the finished pipe.

Further experiments showed that a rather wet mix could be used for the machine-made pipe by slightly increasing the percentage of crushed stone. With the wet mix, water marks appeared on the surface of the finished concrete. The per cent absorption was reduced to 6 per cent and the pipe, with steam curing, passed the strength tests when 3 or 4 days old. No pipe of this last character has as yet been placed in the sea water test, but in so far as strength, per cent absorption and leaks are concerned, this pipe is superior to any of that placed in the sea water test.

The hand-poured pipe removed from the sea in 1925 after ten months' exposure to the tide action showed considerable corrosion of the reinforcing wires. The No. 8½ gauge wires were in several places almost corroded in two. The sea water on penetrating the voids in the concrete traveled for considerable distances along the reinforcing wires from any point of contact with the wire. So far as complete protection of the reinforcing is concerned the concrete in the hand-poured pipe did not provide such protection.

In March, 1926, two more joints of the hand-poured pipe, placed in the sea in 1924, were removed for test; and also

two joints of the machine-made pipe placed in the sea in 1925. Visual inspection of the joints showed a slight increase in the corrosion of the wire in the hand-poured pipe, and practically no corrosion of the wire in the machine-made pipe. All of the joints remaining in the sea are almost completely covered with layers of shells and sea growth, which have effectively closed most of the openings in the concrete surface.

STONE AND GRAVEL ROAD CONSTRUCTION

By J. W. Hoover, State Highway Engineer of Washington.

(A paper read in July, 1926, at meeting of American Society of Civil Engineers at Seattle, Wash.)

Much might be said of the economic value of the type of surfacing to be considered here, of the volume of traffic that will justify the change from a dirt road to a gravel or crushed rock surface and from such surfaces to the more expensive and satisfactory pavement. However, it is assumed that these changes are sound and well recognized in principle. The actual period in the growth of traffic at which each change becomes economically advisable must be determined for each road on its merits. To state that a traffic of 300 cars or 400 cars per day or so many tons per day justify a change of type of surfacing as a general proposition is to err. The cost of each item involved in the maintenance of the existing surface and the cost of each item involved in the construction and maintenance of a higher type of surface vary in each locality. The value worked out for a highway in this state would not serve in another state except as a coincidence; the principal involved is the same, however, and should be based on the various costs as affected by subgrade, traffic and climate.

The most important consideration is certainly overlooked when weighing the dollars involved; that is, service to the public. Just how good a road is the public entitled to have? As a general rule, the automobile owner is supplying the funds; it is his money and his road; how good should it be?

When to Change Type of Surface

A number of the papers published in current magazines fix the time for paving a highway at from 400 to 500 cars per day or approximately the same number of tons per day based on certain average conditions in certain localities. None has been found attempting to fix the volume of traffic considered sufficient to justify gravel surfacing; the general idea seems to be that if a road is worth building at all, a gravel surface is also justified. As a general rule I doubt if many paved roads are carrying less than 1,000 cars per day and certainly thousands of miles of gravel roads are carrying more than 1,500 cars per day.

After all, at the present time the question as to the time to change the type of surface is dependent upon the funds available and seldom upon the real economics of the situation for the reason that we are far behind the requirements of traffic. A very large percentage of the highways of the nation are now carrying more traffic than the width and type of surface justify considering the economic value and the service to which the public feels entitled. The question now is which road shall be improved first and it may be answered on the basis of a traffic study although often the decision is made by the legislative body making the appropriations for highway work, disregarding the merits of the respective roads.

The Subgrade

The subgrade on which the surfacing materials are to be placed should be given such preparation as is necessary to provide a well drained stable foundation. Consideration should be given the soil, practical drainage where necessary and the climate before the selection of the materials to form the surface metal is made and before the width and thickness of surface is determined.

After the value of the subgrade as a foundation has been studied and the present and probable future traffic that the surface will carry is analyzed the metal, either gravel, crushed gravel or crushed rock may be selected. Such selection is a matter of economics with the criterion that the material selected shall give the service required at the least cost. Going hand in hand with the selection of the metal is the matter of the design of the cross-section.

Design of Cross-Section

A surface 12 ft. wide and 6 in. thick is often all that is necessary for light traffic. However, there is and will no doubt be for sometime a very large mileage of unpaved highway that is subjected to traffic in an amount sufficient to justify paving. In selecting a design or surfacing for this traffic as well as for a

volume of traffic for which metal surfacing is suited a cross-section following more closely to pavement design is recommended. The metal should be placed for a width of not less than 18 ft. and should have a thickness at the edges of from 9 to 10 in. and a thickness across the center of from 7 to 8 in. Where the subgrade is unstable additional thickness of metal should be provided. A design similar to the above is of more importance where the more expensive water bound macadams and dust prevention methods through oiling or other surface treatments are contemplated or probable in the near future.

Size of Surfacing Material

The maximum size of gravel or crushed rock was first rather large, often running as high as 3 in. As maintenance methods became more extensive the size was cut down until the extreme of 1½ in. for the base course and ¾ in. for the top course became common with occasional specifications limiting the base rock to a maximum of 1 in. and the top course to ¾ in.

Practically all of these roads were maintained by frequent dragging and the ideal was expressed as a smooth compact base covered with from ½ in. to 1 in. of loose material to be worked back and forth across the road by means of the drag or grader. Highway surface construction passed through the coarse rock stage and there is now a large mileage of fine rock surfacing that may be treated to give a surface free from dust.

There is now developing a tendency to change to coarser rock or gravel in surface treatments to secure a smooth compact surface free from loose material particularly where the travel is heavy and where dust prevention is desirable.

Selection of Surfacing Material

Selection of gravel, crushed gravel or crushed rock as a surfacing material has been based largely on the cost of the material on the road. This has resulted in natural gravel surfaces or crushed gravel surfaces in the glaciated areas. Crushed rock has in general given the best service with crushed gravel and pit run screened gravel in the order named. There are exceptions as some deposits of natural occurring fine gravel can be worked into roadways comparable in every way with the best crushed rock.

The question of hardness of gravel or rock for surfacing has been given a great deal of study and in general the limits set forth in the specifications of the various states no doubt produce good results. It is not practical to use the same specifications in all of the states for the reason that the specifications must be fitted to the materials available, the soil, traffic, and climatic conditions. Very often material is found that would not pass the specified tests, nevertheless it makes the best of road surfacing under the circumstances. The policy of the State of Washington is to test the materials available before the contract is advertised. The bidders are then advised by the special specifications as to the requirements for each grade of material. In this way the contractor is fully advised before making his bid as to the sources of gravel or rock, the element of gamble is materially reduced and the state receives a better bid for the work.

Specifications

Following is a short review of gravel or crushed rock surfacing specifications for a roadway that is to be maintained by dragging loose material back and forth.

The subgrade shall be smooth and true to the required cross section and all large rock removed.

The surfacing material shall be uniformly distributed on the subgrade. If the inspector should be lax in this requirement the surfacing when completed will not be smooth and traffic will work depressions at the point where the material is not uniform and it will be sometime after the work is completed before the maintenance forces can work up a first class riding surface. The usual specifications also require that the contractor insofar as it is practical shall do his hauling over the surfacing as it is placed. In order to accomplish this the surfacing is started at the point of loading or the point of entrance on to the highway and worked away from that point.

It is also necessary to drag the surfacing material as much as is necessary to keep it smooth. Where the surfacing is to be constructed in two courses, the contractor is required to construct as much of the base course as is possible from any one set up of bunkers before beginning the construction of the top course. Where the entire product of the crusher is to be placed in the base course, it is required that the entire base course shall be constructed before starting on the top course and where the product of the crusher is separated into two sizes only the base course shall be constructed until the section of the bunkers for the finer material is filled at

which time the top course may be started. In this way the hauling equipment is used to secure as much compacting of the two courses as is practical. By dragging the surfacing and keeping it smooth the trucks do not run in the same tracks and the traffic is distributed over a wider area.

Binding Material

Very few specifications give sufficient attention to the binding material required to be added to the surfacing. The usual specifications permit the use of side of the road material or any other material that is easily available and having some binding quantities. The binding material should be a water resistent clay, which when mixed with the surfacing material will harden.

The State of Oregon has given this part of the work a great deal of thought and attention during the past few years and has secured very good results.

Too much emphasis cannot be placed upon the necessity for keeping the subgrade smooth and each course of surfacing smooth during the entire operation of constructing the road and afterwards by means of the maintenance organization. The best results are obtained in this type of surfacing by constructing in at least two courses. The base course containing rock having maximum size of 1½ in. and the top course composed of rock which will pass a ¾ in. ring. The two courses should be of equal thickness which should be for each not less than 3 in. The thickness of the surfacing depends upon the character of the subgrade, the traffic and the climatic conditions. In some regions such as the arid regions of Washington where the rainfall is only from 6 to 10 in. per year, light surfacing holds up very well. In other localities a very heavy course of surfacing is necessary by reason of a rainfall that is more than 100 in. per year and a subgrade that becomes very soft when wet. The best results in the heavy rainfall area are obtained by using the product of the crusher in the base course as this builds up into a crust with comparatively little binder due to the interlocking effect of the crushed material. In the arid regions the product of the crusher may be separated into the two sizes and the base course bound up with good clay and the top course placed and bound up with clay. A great variety of specifications for the size of material in each course is possible, dependent upon the materials that are available to provide the facilities for traffic at the least cost.

The available materials should be given thorough study for each project. Of course in some localities there is no choice. Surfacing constructed in more than two courses is often times advisable due to a soft subgrade that cannot be cared for by drainage or by raising the grade line without excessive cost; in some instances a base course of large rock is advisable and economical.

Maintenance

The maintenance of gravel or crushed rock surfaces is based on dragging with a grader or drag having a comparatively long wheel base. Some roads must be dragged more often than others depending on the stability of the subgrade, the character of the surface, the character and volume of traffic and the climatic conditions. Additional material must be added as the original material is ground up and blown away or pounded into the subgrade. The surface must be kept smooth at all times for if it once becomes rough a considerable cost is entailed in scarifying, reshaping and compacting the material into a smooth surface.

The methods of surface treatment with oils developed or in process of development by such states as Oregon, Wisconsin, Michigan, and a number of other states give promise of eliminating the dust nuisance. For some states this surface treatment will necessitate a considerable additional inital outlay as the type of surfacing constructed in the past is not adapted to oil treatment and is less expensive than that which the oil treatment seems to require. While I have not seen the oiled roads of states other than Oregon, I am much pleased with results secured east of the Cascade Mountains in that state and believe that anyone interested can profitably spend a few days studying their methods and results.

There is no final answer—no one final specifications for a modern crushed stone or gravel road; possibly there are but few fundamentals that will apply under all circumstances. The conditions of soil, climate, traffic, materials of construction and funds fix the limits to which construction may be carried. Surfacing of the type discussed in this paper is undergoing thorough research and will be developed to a higher type of construction just as research developed the type of modern pavements. The science of highway engineering has made wonderful strides in the past ten years along

many lines and gives promise of splendid development for the production of a surface to serve adequately and well pending the construction of the higher types of pavement.

STREET PAVEMENT DESIGN IN AKRON, OHIO

By E. A. Kemmler, Highway Engineer, City of Akron

(From a recent issue of "Highway Topics," published by the Ohio Good Roads Federation.)

In designing the bridges for improved roads great pains are taken to ascertain the nature and extent of all the possible destructive forces. The bridge is designed with mathematical exactness. Also the sizes of the openings for all bridges and culverts are computed from rainfall records, high water marks, drainage areas and other data, so that they may be thoroughly adequate.

When we come to the design of the pavement, which constitutes at least 80 per cent of the entire cost of the road, most of us are still doing considerable guessing. Regardless of kind and amount of traffic, soil and climatic conditions, topography, kind of wearing surface and joint filler, the 6-in. concrete base is still the standard of many municipal engineers.

The city of Akron discarded this unscientific practice in 1919, after the annual report of the Highway Engineer for 1918, from which the following paragraph is abstracted, had been received and approved by the Chief Engineer and the Director of Public Service:

"The numerous failures, principally on county road pavements, since the advent of the automobile trucks, gives rise to the conviction that we have been designing pavements according to tradition rather than with the idea of resisting the natural and artificial forces which conspire to destroy them. A 6-in. concrete base for city pavements, and 4-in. for roads, regardless of the kind of wearing surface, or soil conditions, has been the accepted standard for 20 years, and we are still following the custom ,instead of designing the pavement just like any other engineering structure, according to the forces which it must resist."

Since that time we have designed Akron's improvements as near as possible to serve ,the purpose for which they are constructed. One of the first things necessary to be done was the standardization of the various soils, of which we have the following:

(a) Solid Rock (Sandstone)
(b) Gravel and Sand (Perfect sub-drainage)
(c) Sandy Loam (Fair sub-drainage)
(d) Clay (Impervious)
(e) Muck (Poor bearing power)

(b) Gravel and Sand

After looking over the existing street pavement with special reference to the soil conditions we found:

Four-inch brick pavements laid on 4-in. concrete base under soil condition (b) showed no depressions or waves after having been laid from four to six years. (The same pavements are in excellent condition today.) One brick pavement in particular (Crosby Street, from Hall St. to Portage Path) completed in 1912, constructed without any base whatever, on sand, carried the bulk of West Hill traffic for about twelve years without losing its contour and with very little expense for repairs. A brick road in Cuyahoga county, between Willoughby and Painesville, laid fourteen years ago with a 5-in. concrete base, on a gravel subgrade, is almost as good as new today.

The superiority of gravel and sand as a foundation for pavements will scarcely be questioned by any road building engineer of the twentieth century. The only questions arising are those bearing on the kind and depth of the base. There is no danger from upheaval in the spring due to the frost action and consequently no necessity for designing the slab against bending moment. The chief function of the base is to form a suitable crown for contour and to keep the material in the natural foundation in its place. A 3-in. black base may be just as effective as a 6-in. concrete base. It has been demonstrated that a sheet asphalt street laid on a bituminous base will not develop temperature cracks, whereas the contraction cracks in concrete base are almost certain to be extended through the ahphalt wearing surface if base and asphalt are laid during the same season.

(c) Sandy Loam

Sandy clay or loam offers a somewhat different problem. This absorbs moisture very readily, producing frost action in the spring. Vitrified tile sub-drains will help to reduce the amount of moisture, but additional strength is required in the base to resist the tensile stresses arising from frost action due to such percentage of moisture as cannot be eliminated by underdrainage.

(d) Clay Soil

It is practically impossible to improve a clay soil by sub-draining. The excavation might be carried to a depth of 4 to 6 ins. below the sub-grade and a system of cross-drains and a sub-base of screened gravel or crushed stone provided, to replace the clay, which would, doubtlessly improve the situation; or the concrete base can be strengthened by increasing the depth or reinforcing with steel to resist the destroying forces. Examples of asphalt pavements, with 6-in. concrete base, laid on clay soil, lifted as much as 2 to 3 ins. by frost, are not rare. They usually settle back to the original level after the frost is all out, but the intense stresses, caused by such action have not improved the concrete base.

(e) Muck

Muck soil is usually hopeless. We have in Akron certain areas that appear to be bottomless pits filled with black muck, which acts like a rubber sponge and cannot be stabilized in any known manner.

Some pavements have been constructed in the usual manner and have settled from a few inches to two feet in the course of four or five years. Summit County engineers are now attempting to build a brick road over one of these muck deposits; they have dumped no end of gravel and clay on the site of this road, but it disappears about as rapidly as it is hauled in. Eventually, they will be able to get the soil into a state of equilibrium, but it may be necessary to build a temporary gravel road and run traffic over it several years before a permanent improvement can be attempted.

Table I shows the depth of concrete base used in 1925, on type "a" or "b" soil in a number of cities in and around Ohio. Only 9 of the 21 cities take traffic conditions into account in designing the base.

In Akron we have designed our foundations in accordance with soil conditions, using a minimum of 6-in. base on sand and gravel, and a maximum of 8 ins. on clay, together with steel bar reinforcement to bridge soft areas. For the detection of hidden weakness in the sub-grade the same is divided into convenient sections, depending on the grade, by means of earth dams, and flooded for 24 hours. So far we have not taken the character and extent of traffic into consideration, except as to wearing surface, chiefly because of the feverish speed at which it has been necessary to proceed with paving improvements since the war, affording too little time for the study of this element of the design.

The cost of paving has tripled in fifteen years. It is now so high that vacant property in the outlying sections that can stand the assessments is the exception rather than the rule. If a 4 or 5-in. concrete or a 6-in. water bound macadam base, laid on a sand or gravel sub-grade, will produce the same result, under the lightest traffic, as the standard 6 or 7-in. concrete base, it would appear to be good business to use the cheaper construction and save 50 to 60 cts. per sq. yd., for the property owner. Further saving can be made by using 3 or 3½-in. instead of the standard 4-in. paving bricks. In this way it would be possible to bring paved streets within the reach of such sections of the city as are now deprived of them because they will not pay out. Even if such a pavement should last only 15

TABLE I.

Cities	*Proportions*	Traffic: *Light Depth*		*Medium Depth*		*Heavy Depth*	
		Asp.	*Brk.*	*Asp.*	*Brk.*	*Asp.*	*Brk.*
Akron	1-2½-5	7"	6"	7"	6"	7"	6"
Alliance	1-2½-5	6	6	7	6	8	6
Chillicothe	1-2½-5	5	5	....	....	....	....
Cleveland	1-2½-5	6	6	7	6	8	7
Columbus	1-2½-5	6	6	6	6	6	6
Dayton	1-3 -6	6	6	6	6	6	6
Elyria	1-3 -5	6	6	7	7	8	8
Lancaster	1-2½-5	6	5	6	5	7	6
Niles	1-3 -5	6	6	6	6	6	6
Portsmouth	.....	6	6	6	6	7	7
Springfield	.....	....	....	6	6	6	6
Tiffin	1-2½-5	5	....	....	....	....	....
Youngstown	1-3 -6	6	6	6	6	6	6
Zanesville	1-2 -4	6	6	6	6	8	6
Buffalo, N. Y.	1-2½-5	8	8	8	8	8	8
Charleston, S. C.	.....	4	....	5	....	6	....
Detroit, Mich.	1-2½-4½	8	....	8	....	8	....
Evansville, Ind.	.....	5	5	6	5	6	5
New Castle, Pa.	.....	....	....	....	6	....	8
Rochester, N. Y.	1-3 -6	6	6	6	6	6	6
Syracuse, N. Y.	1-3 -6	7	7	7	7	8	8

years the amount saved, with compound interest, would pay for resurfacing with asphalt when it is worn out. This leads to the query: Why not use 8 or 9-in. gutters on all street pavements, so that they can be re-surfaced to better advantage, incidentally preventing many automobiles from climbing them and knocking down lamp posts, street signs, trolley poles, etc.

The writer does not offer the above remarks as gospel, but simply as food for thought. What is the answer?

CONSTRUCTION OF LARGEST SEWER IN GREATER NEW YORK

By Frank W. Skinner, Consulting Engineer, 20 Vesey St., New York City

To carry off the rainfall from about 35,000 acres of level, residential territory in the eastern part of the Borough of Brooklyn, New York, there is now in advanced stage of construction a storm water sewer with a capacity for 18,000 gals. per minute discharged through a receiving chamber already built and an open outlet channel to Jamaica Bay. The sewer is located entirely in a stratum of coarse sand and lies partly above and partly below the ground water line. The alignment follows the center of several important streets and avenues which at the upper end are closely built and paved but at the lower end pass through about 3,000 ft. of unimproved low-lying streets. The sewer was designed under the direction of A. J. Griffin, chief engineer of sewers, Borough of Brooklyn, and its contract for about $3,400,000 was awarded to the Montrose Contracting Company, J. P. Carlin, President.

Beginning with connections at two points with the existing sewer system the minimum section 15 ft. wide and 12½ ft. deep, with vertical side walls 14 ins. thick and a flat roof 18 ins. thick, has gradually increasing dimensions until at the outlet the width over-all is 47 ft., depth 13 ft., thickness of side wall 16ins., and thickness of the horizontal roof slab which is supported by two intermediate partition walls, 22 ins.

The sides of the trench were cut through the street pavement by two pavement busters operating by air from two portable compressors, all made by the Chicago Pneumatic Tool Co.

The entire sewer is constructed in open trench with a maximum width of 52 ft. and of a depth varying from about 25 to 35 ft. Subgrade is in some places several feet below ground water line. Below the top soil 6 to 10 ft. deep, the excavations was entirely through clean coarse sand that was retained on the vertical sides of the trench by 2-in. and 3-in square-edge planks, 16 ft. long, beveled at the bottom and varied in length from 16 and 18 ft. for two sets to 28 ft. for a place on Avenue I where only one set was reqiured.

On the larger and more difficult portion of the trench these sheet piles were driven exclusively by two No. 6 and eight No. 8 double action air operated Union Steam hammers, weighing 850 and 150 lbs. respectively, which delivered 340 and 475 blows per minute and were usually operated in pairs, one on each side of the trench.

The sheeting was braced with from two to five tiers of 8x12-in. transverse struts between which Blaw-Knox Dreadnaught buckets excavated the sand below the limits of operation of the steam shovels and dragline buckets. The buckets handled about 600 yds. of soil each per shift and on a large part of the work were operated exclusively by three K1 60 h.p. and one K2 80 h.p. gasoline engine Link Belt All Purpose Crawler Cranes, with 60 and 50-ft. booms, special dirtproof treads and sturdy standard construction that practically eliminated breakage.

On part of the trench crawler cranes were equipped with steam shovel dippers and excavated to a depth of about 14 ft. below the surface of the street, where they delivered to 5-ton trucks, several of them of the Corbett make. Below the top soil the material encountered was all clean, coarse, sharp pit sand.

On most of the lower section of the sewer it was permissible to store the soil on both sides of the trench, where a 35-ft. clear space was covered with long thick transverse planks providing a floor for the operation of the cranes on both sides of the street. The sand was stored in piles 25 ft. high and when these were not adequate for the large amount derived from the very wide and deep trench the sand was re-handled and the piles were widened on the side away from the trench by the same crawler cranes that eventually reclaimed it for backfill.

On each section, especially in the low ground near the shores of the bay, trench drainage was a serious problem, and,

near the outfall end, was very much facilitated by the construction of an extra width of trench permitting longitudinal drainage ditches to be provided on each side of the sewer construction, thus materially lowering ground water level and carrying the flow as much as 2,000 ft. to a main sump drained by two 8-in. electrically-driven centrifugal pumps.

Where the excavation of the wide trench was in the down-grade direction temporary sumps from 30 to 60 ft. apart were drained by two 6-in. and one 10-in. portable gasoline pumps that were located so as to deliver the water to sewers in transverse streets that were temporarily dammed so as to raise the water level and cause it to flow in the opposite direction to trench sewers in parallel streets.

On the upper section of the sewer, where the excavation was proceeding up grade, the slight amount of dry-weather storm water encountered was generally permitted to spread over the sandy subgrade and disappear there rather than to attempt to carry it over the finished invert and pump it out. The flow that was received from intercepted sewers and from the old sewer that was removed was impounded by sand bag dams and pumped out by two 3-in. discharge gasoline pumping units.

Very thorough provisions were made for maintaining maximum uniformity of progress with all the principal phases of the work so that the concreting could be carried on in regular maximum sections without waiting.

The completed timbering was immediately followed by the laying of the inverts that were placed in 40-ft. sections extending up beyond the fillets connecting it with the vertical side walls. As soon as the concrete was set the invert was paved, a total of about 3,000,000 vitrified bricks being furnished by the A. S. Reid Brick Company.

The 99,000 yds. of 1:2:4 concrete is reinforced with 6,300 tons of deformed steel, mostly Belgian, in 42-ft. lengths, which were cut by oxyacetylene torches and distributed along the sides of the sewer by home made trailers with platforms 44 ft. long, hauled by tractors.

Part of the three-barrel sewer was concreted with 120 lin. ft. of Blaw-Knox adjustable steel forms supported on steel carriages, operated on invert tracks. As it was found that the trench could be prepared for more concreting than those would suffice for, they were supplemented by wooden forms more quickly manufactured by the contractor than could additional steel ones be ordered and received. The remainder of the forms for all parts of the sewer were built at the two field shops by the contractor's forces, and varied somewhat according to the size of the sewer. In some cases the wall forms were single large panels of horizontal planks nailed to vertical transverse pieces and handled by the cranes after they had been stripped, cleaned and oiled in a horizontal position in the invert.

All of the roof slab forms and some of the side-wall forms were supported adjustably from carriages traveling on the invert tracks. The wood forms for the roof slab of the 180-in. sewer were made in 8-ft. sections with a transverse width equal to the distance between the vertical side walls. The 8x9-ft. horizontal surface of the form was made of 2x12-in. dressed boards nailed on top of two pairs of 2x10-in. transverse beams supported on three longitudinal beams 2 ft. apart that were carried on the tops of two 4x4-in. adjustable vertical posts 4 ft. apart on the center line of the sewer. Hinged to the 8-ft. longitudinal edges of the form platform were 90-degree fillets with a 12-in. radius that were kept in place tangent to the horizontal and vertical surfaces by braces. The vertical posts fitted between pairs of transverse side frames and their lower ends were supported on screw jacks on the platform of a 4-wheel truck running on a 5½-ft. gauge invert track.

The 93,000 yds. of 1 to 12-in. broken stone required for aggregate were furnished by the B. Turecamo Construction Company, who handled it from barges to general storage and thence to the sewer by a fleet of 20 Pierce Arrow Trucks, that sometimes delivered 1,000 yds. in one day, and together with the sand, both of which were stored in piles on the surface of the street, were loaded by seven measuring wagon loaders, to 1-yd. dump trucks and dump cars mounted on truck chassis, and delivered together with 400,000 bags of Portland Cement stored on street platforms and protected by tarpaulins, to the concrete mixers, one of which was installed at each separate excavting section of the sewer—six in all.

In order to secure the greatest flexibility and continuity of operation, road paving machines of standard types were used for mixing the concrete. They were mounted on caterpillar tractions and de-

livered to the forms through steel chutes suspended from their booms, or supported on the trench bracing. The wagon dumped directly to the power-elevating hoppers of two Oshkosh, one Ransome, one T. L. Smith, and one Koehring machine, all of which did satisfactory work and chuted most of the concrete directly to the forms, although in some cases it was delivered to trucks carrying it to inaccessible points. The reinforcement bars for the upper part of the sewer were very advantageously bent on a multiple piston hydraulic table devised by Superintendent L. B. Wilcox. This machine made the eight bends of the rather complicated roof slab truss of 1-in. steel in 30 seconds.

After the sewer trench was backfilled the surface was dressed by a road finishing machine.

Operations were commenced April, 1925, and when the work was suspended for the winter in December, 85 per cent of it had been completed, although the contract time for finishing the job was August, 1926. The contractor established his own storage tanks and distributed about 70,000 gals. of gasoline and nearly 4,000 gals. of lubricating oil to the different trucks and machines.

THE ROYAL ORDER OF NEVER AGAIN

By Clark R. Mandigo, in The Constructor

"Why that fellow's bid was below our cost and we didn't figure anything for depreciation and interest on our equipment. We have got to get some work to keep our organization going or we will be up against it." Something like the above can be heard at every letting. In Heaven's name, what is cost if it doesn't include all items of overhead, if it leaves out a fair return on money invested in equipment, if it doesn't provide for repairs and replacement of this equipment when need be? And yes, some place in your cost must be a provision for tiding over periods of slackness in quantity of work such as we are now experiencing, and idle periods between jobs. Aren't these and a lot more items just as much the cost of doing work as the cement or pipe you put into the job?

What are you—business men or lunatics? Business, Industry—Bah! Name a business that is conducted like you conduct yours! Do you ever stop to use your heads or has some strange fever diseased your minds? How long will such foolish bidding keep up and who will be the gainer? We can answer the last question by saying, until you all come to you sense. No one will gain—some will fail, others will report losses.

Some contractors attempt to answer the question by saying "everyone else is doing it," or, "we have got to keep these new fellows out." Who makes the prices of work, if you don't? Isn't that an excuse and not a reason? Wouldn't we have better luck in giving effect to "responsibility and experience" if the fellow just starting in had a bid way low rather than just beating you a few hundreds?

Bidding work below cost is what is now being done. In all the years you have been in business including periods of scarcity of work such as now being experienced, has the below cost bid been helpful or effective? Is that the only effective means you have ever been able to invent to offset cutthroat competition? If your past experiences, your reason, your brains can do no better than that, construction is not a business industry but a madhouse. Surely that isn't the case, there must be some other solution. Think it over and let us have your views.

In the meantime we propose the "Order of Never Again." All you need to do is to hold up your hand and swear to the following declaration: "Never again will I be guilty of agreeing to do construction work at less than cost plus a profit. Never again will I submit a bid for doing construction work without first carefully checking my costs and including therein everything which is a proper charge. Never again will I bid to get a job, try to outguess the other fellow, or forget any of the teachings of my years of experience."

Let's have a large membership list in the "Order of Never Again."

IN SUPPORT OF FEDERAL HIGHWAY AID

(Editor's Note: The following quotations from speeches made in Congress in support of federal highway aid are worthy of preservation. These speeches were made at the recent session of Congress during the debate on the bill continuing the participation of the federal government in road building in the several states.)

Representative C. C. Dowell of Iowa

Some years ago Congress took up the

subject of a national highway system, and since that time there has been a vast improvement in the construction and use of the highways. In 1912 a joint committee was appointed, composed of members of the Senate and members of the House of Representatives, to investigate and report on the subject of what part, if any, the federal government should take in the construction of roads. This committee made a careful investigation of the subject, and reported its findings to the House and Senate in 1915. As a result of this investigation and report, Congress enacted legislation providing for federal aid in the construction of highways.

The first legislation was enacted and approved July 11, 1916. This legislation provided for a five-year program and provided for an appropriation of $75,000,000. Five million dollars became available the first year; $10,000,000 became available the second year; $15,000,000 became available the third year; $20,000,000 became available the fourth year; and $25,000,000 became available the fifth year.

The next legislation was passed in February of 1919 and carried an appropriation of $200,000,000, covering a period of three years. The first $50,000,000 became available immediately; $75,000,000 became available for the fiscal year ending in 1920; and $75,000,000 was available for the fiscal year ending June 30, 1921. Up to this time the action of the government in aiding the states was largely experimental.

In 1921, after a careful investigation and consideration of the whole subject, legislation was enacted providing for a comprehensive program of federal aid in the construction of highways. This legislation provided for a program of road construction throughout the entire nation, embracing 7 percent of the roads in each state, and this 7 percent aggregates approximately 200,000 miles of primary and secondary roads. This act established for the first time a definite governmental policy and program for cooperation with the several states in the construction and maintenance of a national highway system. Seventy-five million dollars was authorized for this work in the first year.

In 1922, following the general program outlined, Congress authorized the expenditure of $50,000,000 for the fiscal year ending June 30, 1923; $65,000,000 for the fiscal year ending June 30, 1924; and $75,000,000 for the fiscal year ending June 30, 1925.

In 1925 Congress authorized the expenditure of $75,000,000 for the fiscal year ending June 30, 1926, and $75,000,000 for the fiscal year ending June 30, 1927. The present bill provides for an authorization for the fiscal years ending in 1928 and 1929. Briefly, this is a review of all the moneys authorized and appropriated by the government for federal aid in the construction of good roads under the highway act.

Under the present law the federal government apportions these appropriations to the several states, and these funds are used in the construction of roads approved by the Secretary of Agriculture. Federal participation can not under the law exceed 50 percent of the cost of construction of the roads or exceed $15,000 per mile.

There are more than 3,000,000 miles of roads in the United States. The Post Office Department is daily using 1,205,500 miles of highway in the delivery and collection of the United States mails. Many miles of these roads are practically impassable at certain seasons of the year, and they are used at great cost and inconvenience. The improvement of these roads will greatly increase the length of the mail routes, will greatly improve the efficiency of the mail service, and will greatly decrease the cost of the government. Thirty million sixty thousand eight hundred and sixteen individuals or rural-delivery patrons are served along this mileage, and many millions more will be added to this number as the service can be extended.

It is interesting to note that five years ago 43 percent of the rural carriers were using horse-drawn vehicles upon their routes, while today but 15 percent are using horses. Also the time involved in the delivery of rural mails has been reduced one-half. *But even under the present program the government is only aiding in the improvement of approximately 200,000 miles of this more than 1,000,000 miles of rural-mail mileage.*

With the great increase in highway construction and the great increase in automobile traffic, the problem of better traffic regulations has become an important factor in the economic use of highways throughout the country.

Some time ago the American Association of State Highway Officials took up the subject of a uniform system of markings and signals on the interstate highways. Last year the Secretary of Ag-

riculture appointed a joint board from the Bureau of Public Roads and the state highway departments to investigate and recommend a uniform system for markings and signals on the principal highways of the country.

This board made a careful investigation of the subject and submitted its report to the Secretary of Agriculture and to the several states, recommending a uniform system of markings and signals. The evidence before the Committee on Roads a short time ago indicates that the system recommended has been favorably received in the several states by their state highway commissions, and it is hoped that out of this will grow a uniformity of markings and signals, to the great aid and safety of motorists on the highways.

It is also apparent that uniform laws and regulations must be adopted in the several states for the better protection of the motorist, pedestrian, and others on the streets and highways. And just a few days ago the Second National Conference on Street and Highway Safety met in the city of Washington for the purpose of working out and submitting to the several states a uniform system of laws and regulations for the government and control of highway traffic. It is hoped that growing out of these conferences and the efforts of experts to work out a uniform system that much may be done in the saving of property and of human life.

The 20,000,000 motor vehicles now on the streets and highways have brought to our attention in a forceful way an appalling record of accidents, injuries, and deaths.

The committee on statistics of the National Conference on Street and Highway Safety report that during the year 1923 there occurred 22,600 deaths as a result of street and highway accidents, and estimated the number of serious personal-injury accidents at 678,000.

In 1924, 23,921 persons lost their lives as a result of street and highway accidents, and more than 500,000 persons received serious personal injuries.

With gasoline costing 20 cents per gallon, the gasoline cost of operating a motor vehicle on a dirt road is approximately 1.43 cents per ton-mile. On gravel roads the cost is approximately 0.95 of a cent per ton-mile and on hard-surfaced roads approximately 0.64 of a cent per ton-mile.

The saving of gasoline in the operation of a car, however, is only one of the many items which go to make up the cost. Excluding the fixed items, such as taxes, license fees, and garage, which are not affected by road conditions, the experts claim that all other charges for operation and maintenance of a motor vehicle are affected in a like ratio, and in summing up the aggregate cost of owning and operating a motor vehicle the experts claim that the cost of operating a car over a gravel road is much less than over a dirt road. And the cost of operating a car over a hard-surfaced road is one-fourth less than operating it over a dirt road.

From estimates made by the National Automobile Chamber of Commerce, the Bureau of Public Roads and the American Association of State Highway Officials, the estimated value of motor vehicles in the United States in 1925 was approximately $16,500,000,000. These estimates further indicate the American people are operating these automobiles on the streets and highways at the enormous cost of more than $11,000,000,000 annually. This estimate does not include garage, driver's wages, and oils. And I saw a statement the other day issued by the Associated Press which included these items, and this estimate aggregated $14,000,000,000, a sum in excess of one-half of the entire national debt. This huge annual outlay can not be imagined or understood until it is reduced to the individual automobile, but when we take into consideration that there are 20,000,000 motor vehicles in operation, we see it only requires an average outlay of approximately $600 to $700 per annum on each car to aggregate this vast sum.

With this vast investment and this enormous annual cost of operation, it is plain to everyone that a great system of highways is imperative. While the federal aid program is far from completed, great strides have been made in the past few years in the improvement of this system.

Representative Frank Gardner, Indiana

Some of the larger cities, or some of the wealthier states, may contend that under this system of road building that particular city or state is paying more than its just proportion of taxes for road purposes. It may be paying out more money than it is receiving, yet these roads are bringing into that city, or that state, the products and necessaries of life from the states receiving this benefit. The mines, and the agricultural fields of the west, in many instances, are sending their products to such cities and such

states. Life insurance companies, banking institutions, manufacturing establishments, and other institutions receive much of their profits from states other than their own. And many of the stockholders, and others contributing to the profits of these institutions, are residents of other states. And it is just and equitable that these wealthier centers should contribute their pro rata part in the way of taxation to this federal-aid system of road construction. I hope that this bill continuing the appropriation of federal aid to the states for road construction will pass without opposition. I also hope that many more such appropriations will be made extending the life of the system for years to come.

Many states are not financially able to construct roads that will accommodate the traffic of today. Yet the public wants to travel through these townships, these counties, and these states that are unable financially to construct these roads, and there is no other alternative but to make the Federal Government the unit for the taxation and the construction of the main market roads. And many of the roads now are used more for the through traffic than they are used by the persons residing along the roads. For that reason it is proper and right that the Federal Government and the taxpayers of the Federal Government should bear a part of the expenditure of the construction of roads in the various states.

In Indiana the State Highway Commission, aided by the funds from the Federal Government, has constructed, and is constructing, the main market highways of the State. And, under our state laws, the counties and the townships are constructing roads to connect with these main market highways. * * *

This same principle of finding a larger unit is recognized in many of our State school systems. In the State of Indiana, for instance, we have a law that any township, or municipality, after levying and collecting a certain rate on the taxable property of that municipality, and it is found to be insufficient to maintain the schools for the length of time required by the State law, that municipality may then draw on the State funds for a sufficient amount to continue the schools.

And in addition to contributing to the national wealth, I know of no appropriation that has done so much to improve conditions and bring about enlightenment as has this system of extending federal aid to the states for road improvement. * * * The State recognizes the fact that it can not permit the children of any part of the state to be deprived of the necessary training in school because of the lack of funds in that particular municipality, thus recognizing the fact that a township, or a county, is too small a unit for the school system, and the same is equally true with the road system.

I know of no one thing that has done more in improving conditions in the State of Indiana than has the improvement of its roads. And I think what is true of that State is true of all states. It has brought the farmers closer to the markets. It has opened up many sections of country to development that were practically inaccessible before good roads were built through those sections. Many sections of the country, where but a few years ago farmers had difficulty in marketing their crops and live stock, on account of the condition of the highways, today are putting their products and live stock in the market, 25, 50, and more, miles away by use of trucks going over good roads to these markets. Schools are being consolidated, and the school children carried in automobiles to the schools; rural mail routes are going over these roads carrying daily papers and other mail to the citizens of the rural districts in automobiles in about one-half of the time that it took the mail carrier of a few years ago to deliver mail on these routes with the horse-drawn vehicle. *While the construction of good roads has brought about a wonderful improvement in the rural districts, yet this road-building program is still in its infancy.*

Senator L. C. Phipps, Colorado

Now, Mr. President, we come to an objection which I dislike to mention. Briefly, it is that some states are poor; others rich; some states contribute small amounts to the United States Treasury; others pay heavily toward the total sum of Federal expenses; and that it is therefore grossly unfair to tax the older, richer, more populous states for road construction in any other part of the union. That is the argument, Mr. President, in a nutshell. That is all there is to it. Think of it. The opponents of state aid can not deny that the postal patron is immeasurably benefited; they can not gainsay that the military arm is strengthened in defense; they can not question that interstate commerce is facilitated; they do not contradict what has been said as to substantial benefits obtained by the farmer, the city dweller,

the traveler, the manufacturer, and the consumer; in short, by all our citizens. They are forced to admit that all these worth-while results flow from Federal highway aid. All they say is that, notwithstanding these benefits, such appropriations should be forthwith abolished because Colorado, for example, with its expanse of territory, its virgin soil, its huge amount of public lands, its thousands of square miles of national forests and national parks, its potential, but not immediately available wealth, does not pay as great a Federal tax as the smaller, old, and richer state of Maryland. * * *

Let us examine this argument for a moment. Let us see how fairly these gentlemen present their case and what reasons they advance for their contention that the West and South are the recipients of special privilege at the expense of the northeastern section of the country. Much is made of the fact that huge income taxes are paid in the East. These tabulations are submitted by the opponents of state aid, and it is said that they afford an excellent basis of comparison, and that from the amount of such taxes paid in each state we can determine the contribution of its people to the expenses of the Federal government and the portion, I assume, in which that money should be doled back to the several states. Great emphasis is laid upon this fact—for it is a fact—that the bulk of federal income taxes are paid in such states as New York and Pennsylvania. The former, for example, should be credited with 28.8 per cent of the total internal revenue collected by the United States, and 15 states in all apparently contribute over 80 per cent of the entire amount received from such sources. But those who advance this argument deliberately shut their eyes to what the Treasury Department itself says about these collections.

I must remind Senators that, for many other purposes not as useful as good roads, not as universally beneficial in their results, Federal aid has been extended to the states or to certain sections of the country, with little or no protest on the part of those who derive no benefit therefrom. For example, take our annual river and harbor appropriations, including flood control. For the period of 10 years, from 1916 to 1925, inclusive—the same length of time during which highway aid has been extended to the states—such river and harbor appropriations have totaled $454,000,000 for expenditure in a limited number of states; whereas the appropriations for good roads, amounting to $540,000,000, were distributed over the entire 48 states of the union.

I am willing to admit that improvement in our national commerce aids the whole country and therefore the state which I represent, in part, in this body. Yet not one cent for river and harbor work is expended in Colorado, which does not have a single navigable stream within its boundaries or on its borders and is a thousand miles away from the nearest harbor. But good-roads opponents exclaim: "That is entirely different. There is no relation between these measures." On my part, I fail to see any difference in principle, and, so far as actual benefits to the public are concerned, any comparison is decidedly in favor of the good-roads program. As to the system itself, there is this distinction, that Federal-aid roads are built on a 50-50 basis, whereas river and harbor work is often done entirely at the expense of the Federal government. Our opponents can derive little aid or comfort out of that, for again the comparison is in favor of good roads.

Take, again, one single project, which is not included in the above figures. I refer to the Panama Canal, an undertaking which originally cost $379,000,000, much more than half our total Federal-highway expenditures to date. Incidentally the maintenance cost runs over half a million dollars each year. The canal has reduced transportation charges from coast to coast, but it has not helped the rate situation in the middle west. In fact, it has had the contrary effect and. by reason of the extremely low water rate from the East, has closed Pacific coast markets to many commodities formerly shipped from Colorado, Nebraska, and other states similarly situated. That is a story in itself, which I have discussed in more detail in connection with another legislative proposal, the Gooding long and short haul bill. *The point I am now making is that Eastern states, which are now reaping rich benefits because of the shipment of their commodities through the Panama Canal, should be the last to complain about Federal aid to another means of transportation which benefits not only the West and the South, but also the entire country.*

But why add illustration upon illustration? The West does not begrudge Federal appropriations for river and harbor improvements or for similar purposes.

At this time in our history, after so

much has been accomplished with Federal aid in certain sections of the country, it will hardly do for representatives of those sections to raise pious hands in holy horror at the granting of an alleged subsidy which will be of immeasurable value in the development of natural resources in other portions of our great land.

Mr. President, it should not be necessary for me to state that this is not a sectional question in any sense of the word and that I am not pleading for the West or South as against the East. Neither am I pleading for national rights as against state rights. There is no real question of sectionalism or sovereign rights involved in this issue. To forget state lines in matters of this kind is not only good statesmanship; it is also good business. All must prosper or the whole nation suffers. That which aids conditions in the agricultural, stock-raising, or mining sections brings increased business to the manufacturing and shipping centers. Factional strife, petty jealousies, and internal discord destroy public confidence in all industrial and agricultural pursuits and spell decay instead of progress. * * *

A somewhat similar question is involved when it is suggested that this plan, which has been in operation for 10 years, conflicts with state rights. Again the matter of public policy is brought forward, and it is insisted that it is the right as well as the duty of a state to construct, maintain, and improve all the roads within its boundaries. For my part I have become convinced that this is a joint duty and that the matter is too far-reaching from every point of view to place full responsibility either upon the individual states or the Federal government. If historical precedent is desired, I could quote Thomas Jefferson, the advocate of state rights, who on many occasions urged the use of public money to open roads, rivers, and canals. Or I could point to Alexander Hamilton, the Federalist, who characterized road building as an object well worthy of the national purse who insisted that to provide roads and bridges was within the direct purview of the constitution. I could summon as witnesses Henry Clay, John C. Calhoun, and that great expounder of the constitution himself, Daniel Webster, all of whom, with broad vision and noble foresight, urged cooperative road building between the states and the central government.

Besides, as a practical matter, there has been no baneful coercion, no undue influence exerted by the Federal Government upon the States in the selection of highways or the actual performance of the work. *I challenge those who object to the system on principle to cite any case of consequence where the State's prerogatives have been assailed or the will of the people thwarted.* State highway officials are making no complaint. The bureau has gone about its work in a fair-minded, systematic manner, and there has been nothing capricious or arbitrary in its decisions. In other words, the intent and purpose of the act has been carried out. There has been full co-operation as to the roads selected and the construction work accomplished. Millions have been saved through co-operation and the interchange of practical information. The bureau has encouraged the establishment of testing laboratories in the various States, with the result that the number of States boasting such facilities has increased from 5 to 44 during the past nine years. Truly, both political parties were wise when they included in the national platforms of the last campaign definite pledges for the continuance of the policy of Federal aid.

In addition, Federal aid has accomplished two results which, in my opinion, far outweigh the amounts actually contributed by the United States for such work in the several States. First, it has established a connected and comprehensive system. It has directed such development in channels where the most good to the greatest number could be obtained. Almost from the start, it was recognized that there are main arteries of travel in each State, running from one large city to another, and feeding the principal local roads of every section of the State. Moreover, there are routes which are also of interstate importance, through routes which are part of a chain joining the principal communities of the Nation and running across the continent. To encourage the improvement of such roads, to prevent the people's money from being dribbled away in small quantities on isolated projects is one of the objects of the Federal aid program. Thus, through Federal aid we build highways where they are most needed. Nearly every city of 5,000 population or more is reached by this system, and, as I have heretofore stated, 90 percent of our people are within 10 miles of a Federal aid road.

The second beneficial result to which I

call attention is also significant. The adoption of this plan has aroused the interest of the state and county authorities generally, so that now, realizing the great benefits of improved roads, they are desirous of expending their allotments of Federal money over the greatest mileage permissible and of improving feeder routes to connect with the main thoroughfares.

This movement has developed into a general road construction program, so that at the present time the contributions of the Federal government only constitute 8 percent of the total annual expenditures for highway construction in the entire country.

When this system was first introduced in 1916, 17 of the 48 states had no highway departments, and the fact that everyone of them now maintains such departments illustrates the helpful aid of the federal good roads law.

Mr. President, there should be no cause to regret that the states have embarked on a program of good-road construction; the only pity is that they were not induced to begin earlier. There remains much to be accomplished, as the development of motor vehicles is still in advance of the road improvement and construction. Therefore, the Federal government should continue to lead the way until all of the states on this continent are bound together with a network of modern highways.

What does Federal highway aid mean from a military standpoint? I need hardly propound this question to senators who have fresh in their recollections the lessons of the Great War. At that time the railroads did their share; there was no physical breakdown; and yet we know how all transportation suffered because of lack of capacity to handle the load. It was then that the War Department turned to the highway system, making use of such routes as we had to transport munitions and other war supplies from point of manufacture to the seaboard for shipment across the Atlantic. Military authorities are still testing the roads by the movement of troops and supplies so as to know what they may count upon in the event of an emergency.

There is another use of the roads for national defense which is sometimes overlooked. It was succinctly expressed by General Pershing when he appeared before our Post Office Committee in 1921 and said:

"The country road will be of tremendous value in time of war. These roads must be relied upon to obtain the needed food supplies."

Permit me to state that adequate highway transportation is just as important from that standpoint as many direct activities of the War and Navy Departments. Do you know that the United States Bureau of Public Roads recognizes this fact, and that ever since the cooperative work was undertaken all Federal-aid roads are so constructed that the culverts and bridges shall meet the needs and requirements of the Army? The War Department was also consulted as to the greatest national need for defense purposes before the present Federal-aid routes were finally approved.

In addition prompt delivery of rural mails is not only a convenience but a necessity to the modern farmer, who transacts much business by parcel post. He buys in that fashion. He often sells in the same manner. The parcel post business, which has grown to enormous proportions in the past few years, affords such substantial benefits to the farmer as to justify the expense and effort required on the part of our Government. With our old highways most of the mail deliveries now being made daily would have been utterly impossible, and the few deliveries that could have been made over such poor roads would have proved extremely expensive. Thus, while the Federal-aid system has enabled the Post Office Department to extend its beneficent arm to practically our entire population, instead of merely assisting those in urban centers it has also permitted the development of these postal facilities at a minimum of expense to the patron of our rural routes and to the taxpayers themselves. Through star routes, which dèliver mail from one post office to another, whole towns which do not enjoy railroad facilities have been put on the map from a postal standpoint.

As to the delivery of first-class mail, good roads are also playing an invaluable part in rural sections. And I insist, Mr. President, that wherever possible the man on the farm is just as much entitled to this great convenience, to this helpful service on the part of his Government as is the city dweller.

I wish to go on record as stating that motor travel is the leaven which is helping to promote the national welfare, to give our people a better understanding of each other, and to furnish them with

first-hand knowledge of varying conditions throughout this, their own country, of our huge natural resources and unbounded national possibilities. Such observations in themselves make men and women better American citizens. They stimulate development of our resources through investment of time, labor, and capital; lead to the adoption of a higher standard of living and to the general enlightenment of all our people. They knit together this union of inseparable states, for they give the American citizen a national viewpoint. *These things, Mr. President, which can not be reckoned in terms of dollars, although they do affect the country's prosperity, these things are made possible by the automobile and the network of improved highways over which it travels.*

It is quite generally admitted upon this floor that additional relief for agricultural conditions is still required and that something should be attempted to that end by legislative act. I myself have introduced and am urging the passage of two bills, which are intended to assist the stockman of the West and through him the entire country. I shall be glad to examine carefully any other agricultural-aid proposals that may be brought forward by my colleagues in the Senate or in the House of Representatives. But, Senators, *I respectfully submit that Federal highway aid has done more in this direction than any other single act of the national Congress and that to abolish the system at this time would probably be the most disastrous blow that could be dealt the American farmer.* * * *

But to return to the farmer. Farm-to-market roads are no myth. In these latter years the transportation of agricultural products direct to the market has been made possible by the program of highway construction. Formerly three hauls at least were required—the slow journey to the railroad over unimproved country roads, the trip by train, and the haul to the commission house or retail dealer. But the motor truck has taken the place of the old arrangement. It has proved especially important in the handling of perishables. It has widened the market; for while the railroad is still available for transportation over long distances, the automobile supplies closer communities which heretofore it had not been possible to reach by railroad.

These agencies of transportation bear the same relation to the commerce of the nation as the blood vessels bear to the human body. These arteries of commerce must be constructed and maintained in a vigorous and healthy condition to severe the nation. No one discounts the importance of the railroads and rivers; but are not the highways more important? The highways touch every community, large and small, and all of the sources of production and every American home. Perhaps more than 65 per cent of all the freight and passenger transportation of the country are moved over the highways; and, in fact, all of the commerce is moved in part of its journey over some highway. There are sections of the country in which we must have the water transportation. I think it might be safely said now that water and rail transportation must take care of the long haul for passengers and freight and the heavy haul for freight. The motor transport can not successfully compete with water or rail in long haul of passengers, or freight, or the heavy-load freight. On the other hand, neither rail nor water transportation can successfully compete or satisfy our present social and commercial life in the short haul of passengers and light freight.

Senator T. L. Oddie, Nevada

One of the latest and most popular arguments against Federal aid is that it is unfair to compel the Eastern states to pay for highway improvements in the West. The premise on which this argument is based is unsound. It presupposes that the real source of Federal taxes is circumscribed by state lines, and that a Federal function to be properly fulfilled should benefit all states in direct proportion to the tax revenue received through them. It overlooks entirely basic facts that are fundamental to our government. *Our states are political and not economic units, and our system of Federal taxation is such that the revenues collected from any one state are in no way a true indication of the creation of the wealth or use or consumption of the products taxed within the particular state.* Furthermore, if the benefit theory be sound, why would it be necessary to centralize certain important powers in a Federal government at all? Would it not be just as easy to operate as a federation of states? On March 10 of this year I discussed this matter on the floor of the Senate and had placed in the RECORD two very able and illuminating articles bearing on this ques-

tion, one entitled "A billion for highways! Who pays the bill?" by A. J. Brosseau, director of the National Automobile Chamber of Commerce, and appearing in Nation's Business of January, 1926, and the other article, entitled "Who pays Uncle Sam's bill?" made by the American Association of State Highway Officials.

Our national needs are such that we must have improved roads; and these needs can be adequately served by the Federal aid road system authorized by the Federal highway act of 1921, which provides for a complete network of interstate highways gridironing the country in such a manner that no person will be compelled to live at any point more than 10 miles from a road improved with Federal aid. Only then will the Federal obligation be fulfilled. * * *

The practice of penny-wise economy on roads by any political agency is to be deplored, particularly when the cure is much less costly than the ailment.

We have approximately 12,000 miles of coast and border line. It is absolutely necessary that there be improved highways following these boundaries. Back of what might be our first line of defense at any time, there should be numerous other trunk highways improved to the extent that they might be used, if necessary, as our second, third, fourth and fifth lines of defense. I am referring particularly to the seacoast. These in turn must be connected with each other and with our various manufacturing or agricultural centers so that the whole will form a complete network of highways gridironing the nation. *We must not lose sight of the necessity of completing as soon as possible our system of transcontinental highways from coast to coast as a military precaution to supplement the railroads in an emergency.*

During a military emergency it is often impracticable to transport materials or men other than over highways, and the difference between victory and defeat may depend largely upon the condition of the highways over which vehicles commandeered for the emergency must travel speedily and heavily loaded. We need no better examples of the value of improved roads during a military emergency than those still fresh in our minds as the result of the late World War.

The carriage of the mails is a national function and one that is specifically provided for in our Federal constitution. The accepted modes of transportation of the mails are by rail, water, air, or over the highways. Obviously the first three are of importance only in the carriage between points of collection and distribution and even then only over great distances. For short hauls and house-to-house delivery the carrier must travel either by automobile, by horse-drawn vehicle, or on foot. Rural carriers are paid on the basis of the standard route of 24 miles. Their annual salaries are computed on the basis of $75 per mile. *By reason of road improvements and the consequent ability of rural carriers to use motor vehicles instead of horse-drawn vehicles throughout most of the year, carriers have been able to take on much larger routes than the standard.* For each additional mile so taken on they are paid $30 annually. By the consolidation of routes and the extension of rural service beyond the standard mileage the carriers have added $30 annually to their income and the Post Office Department has saved $45. This saving alone, due to improved post roads, amounts to more than $7,000,000 per year. What the saving to the public through increased efficiency in the Postal Service, particularly through the lessening of time for deliveries, together with direct savings to the carriers through lower depreciation and operating costs of their vehicles, has not been estimated, but in my opinion it is very substantial and exceeds greatly the known savings to the department in salaries. Experience has shown conclusively that the building of good roads has made it possible to transmit the mails more quickly and more economically.

Government surveys show that the farmer using motor equipment has quadrupled the economic range in his choice of markets. This has enabled him to take advantage of more favorable prices at a greater distance. In a great number of cases it has resulted in direct sales to the consumer of his products, which otherwise would remain unproduced or unsold. On the other hand, cooperative truck service, where it exists, has relieved him of the necessity of taking his goods to market and has permitted the farmer to remain a producer and not a transporter or marketer. The result is that more farm products are being produced, much of which is being marketed, that in the past was largely permitted to go to waste. Frequently the farmer has been brought within

reach of a large city and enabled to turn from the production of low-value crop to perishable and more valuable products.

One of the most important things that the farmer obtains from improved highways is increased marketing facility by the hauling of various farm commodities into the cities by motor truck. The truck passes the farmer's gate, thereby furnishing a service which can not be duplicated by the railroads. In this way the cost of distribution of agricultural products has been materially reduced. Let us take the distribution of milk as an example. Experts declare the shipment by truck instead of by rail has reduced the number of handlings from six to only two. Heretofore the farmer had to haul his milk to the local shipping point, then it was hauled by rail to the city, and then the city distributer had to go to the milk platforms and get it. Now it comes right from the farmer to the city distributer's place of business.

The problem of good roads in the farming areas is one of the major problems of this complex industry. Good roads play a highly important part in making life on the farm more agreeable and profitable. It is very evident that the gains to the farmer from good roads are large, consequently adequate farm relief and the continuation of federal aid on roads must go hand in hand. * * *

Another economy of improved highways is to be found in the effect they have on land values. When the Bureau of the Census was collecting data for its report on the "Estimated national wealth," our government experts gave much thought to the question of how to determine the real value added to national wealth by improved highways. Some thought that the true figure was the replacement expense of highway improvements at present costs with an adequate allowance for depreciation of the improvement since it was made. It was finally decided, however, that the real value of such improvements must be largely, if not entirely, reflected in the value of the real property which the improved highways served, not necessarily in the value of the property along the highways or within any stated distance from them, but somewhere in the United States. In other words, the value of highway improvements is national and not local, and in not accepting replacement costs less depreciation as the true value of highway improvement, it may be reasonably assumed that these experts considered the actual value as greatly in excess thereof.

From an economic standpoint the increase in land values and the direct savings in operating costs of motor vehicles using the highways would seem to fully justify not only the expenditures we are making at the present time but considerably more. The computations made, however, have not taken into account the huge economic value of improved highways in facilitating the transportation of persons as well as agricultural and industrial products. Nor does it include any allowance for the added efficiency of the American business man today, which is estimated at 57 percent where he is able to use an automobile. Nor does it include the noncommercial utility of the motor vehicles such as time saved outside of business and in healthful recreation. Nor does it make allowance for the stimulating effect improved roads have had upon the more extensive use of motor vehicles and in turn the effect the expansion of the automobile industry has had upon the prosperity of the nation. This industry alone is responsible directly for the livelihood of more than 3,200,000 persons and indirectly for the happiness and prosperity of the entire nation. During the 25 years of its existence the automobile industry has grown until now it is our most important manufacture, rated according to wholesale value. In 1925 the total wholesale value of cars and trucks reached the stupendous sum of $3,000,000,000, while the wholesale value of parts and accessories and tires amounted to almost $2,000,000,000 more. Consider the interdependence of the automobile industry and highway building and the ultimate effect of these on the country at large. They have assumed the proportions of a national need.

In appraising the economic value of the automotive industry I should not fail to mention the real effect the use of its product has had on other transportation facilities. Often it is said that the use of the automobile, the bus, and the truck is crowding other freight and passenger carriers out of the transportation field. But is this the fact?

Representative W. M. Whittington, Mississippi

There has been a campaign against Federal aid. Those who oppose Federal aid argue that it is a departure from our system of government; that it pro-

motes centralization; that it fosters bureaucracy; that it deprives the states of their independence and initiative; and that its tendency is toward the breaking down of local self-government. I am opposed to centralization, to bureaucracy, and to the Federal government doing any of those things that can be done by the states and their subdivisions. I know that the government is best that is closest to the people. However, there are many instances where there should be co-operation between the State and the Nation. In all matters the State must maintain its independence.

In Federal aid to highways the state is not deprived of any of its rights. There is no tendency to centralization in Washington. The contracts are made by the state authorities; the roads under the laws of the state, and the funds contributed by the Federal government are disbursed by the State Highway Commission. This is as it should be, for I would oppose the surrender of the independence of the state and the transfer of its funds to the Federal government in the construction of highways that received Federal aid.

Moreover, in Federal aid to highways the state is not sacrificing its initiative. The United States aids in the construction of the main highways to the extent of about 7 per cent of all roads in the states. The facts are that the states that have the best main thoroughfares have the finest system of lateral roads. The initiative of the states is being developed by the help of the Federal government. Federal aid is helping and not hindering in road construction.

The states must never sacrifice their sovereignty to secure Federal aid. In accepting aid for roads local self-government is not destroyed and the rights of the states are not surrendered.

The Federal government has always been interested in the matter of transportation. Without Federal aid the transcontinental railroads could never have been built. It is said that the Federal government granted lands to the transcontinental railroads that aggregated more than the entire area of the states of Iowa, Illinois, Indiana, Ohio, Michigan, and Wisconsin. If the Federal government was justified in promoting railroads, surely it is more justified in supplementing the transportation of the railroads by aiding the highways.

Our government is a dual form, and it involves a dual citizenship. We are citizens of the United States, and we are citizens of our respective states. We are neighbors and brothers largely because of better means of travel and communication. The nation is vitally interested in lending a helping hand to the states. We are citizens of a common country. Every state is interested in every other state. *It is the duty of the government to provide for the welfare of all the citizens.* Mr. Justice McKenna expressed this thought when, speaking for the Supreme Court of the United States, he said:

"Our dual form of government has its perplexities; state and nation have different spheres of jurisdiction, as we have said; but it must be kept in mind that we are one people, and that powers reserved to the states and those conferred on the nation are adapted to be exercised, either independently or concurrently, to promote the general welfare, material and moral."

FINANCING WATER WORKS PROJECTS

By C. N. Phillips, of J. H. Causey Co., Denver, Colo.

(A paper read before 1926 meeting of Rocky Mountain Section of American Water Works Association.)

It is my intention to discuss the financing of water works projects from the standpoint of several years' experience as a dealer in municipal securities. Theoretically two methods of financing are open to a municipal corporation desiring either to construct a water system, purchase a water system, or make substantial improvements or extensions to a system it already owns. These two methods are the payment of the cost from current revenues or by borrowing on the credit of the municipality through the medium of long time municipal water bonds. Practically speaking in almost every instance the capital expenditure required is too great to be paid out of current revenues and I shall, therefore, deal with the financing of such projects by the issuance of municipal water bonds.

Municipal corporations have authority to issue bonds only as such authority is specifically granted by statute. The laws of the various states outline in detail the necessary steps to be taken, usually specify the maximum rate of interest such bonds may bear and contain certain restrictions as to the maturity of

the bonds, price at which they may be sold, etc. In the three states of Colorado, Wyoming and New Mexico, there is a very wide divergence so far as certain features of these laws are concerned. I shall not bore you with a detailed resume of these laws, but shall endeavor to outline certain principles and methods of procedure which it seems to me should be followed out as nearly as may be under the legal restrictions imposed by these laws. In so doing, I will have occasion to mention some of the outstanding features of these laws which must be taken into consideration.

The First Steps

When a bond issue is contemplated the first thing, naturally, to be determined is the maximum amount of bonds to be authorized. So far as this is concerned, we have no legal restriction in any one of these three states, as their constitutions specifically exempt waterworks bonds from the operation of debt limits imposed for other purposes. This is also the case in most of the states throughout the country. There is good sound reason for this, particularly in the West. A good water supply is, of course, the most important requisite to a community of any size and in the West it is often necessary for municipalities to incur, and rightly so, a heavy amount of indebtedness in order to secure an adequate water supply. There is another reason for exempting the water debt from the operation of a debt limit and that is the fact that the revenues from the operation of the plant should, in addition to operating and maintaining the system, contribute substantially to the amount of money required for principal and interest on outstanding bonds, which I shall refer to as debt service. Of course, there is this to be said, except in certain very small communities where it would be impossible to charge a sufficient rate for water to provide all of the necessary funds and it is consequently imperative to depend partly on taxation, the question of whether this money comes from water sales or taxation is principally one of policy and bookkeeping.

Engineering Advice Should Be Obtained

Therefore, as to the amount of indebtedness which may be incurred, a municipality is limited only by the amount the taxpayers are willing to authorize and its ability to sell its bonds. It seems to me that public officials contemplating a bond issue for water works owe it to the taxpayers of the community as a first step to obtain adequate and competent engineering advice as to the original cost of a project and also the operating cost after it has been constructed, so that the taxpayer can be fully informed and exercise a really intelligent decision when he goes to the polls to vote on a bond issue. The taxpayers are entitled to this information, because in the final analysis municipal water bonds are secured by the taxing power of the municipality and not by the earnings of the water system. An ample amount should be included because any municipality has authority to issue a less amount of bonds than have been voted if the entire amount is not needed.

Outside of the duty to the property owners, our New Mexico friends find it practically imperative to know how much they will need when they start, because in New Mexico a bond issue can be submitted at regular municipal elections which occur only every two years and so it is extremely important that sufficient funds be provided in advance to complete any project which is undertaken. In Colorado municipal officials have more leeway. In fact municipal officials in Colorado are given more authority in this respect than in any other state with which I am familiar. When an election has once been held in a municipality in Colorado and the erection or purchase of a water plant has been authorized by the taxpayers, the city council or board of trustees has power and authority, without again going to the voters, to issue whatever amount of bonds may be necessary, in their judgment, such action, of course, being subject to the referendum. Wyoming requires an election for each bond issue, but permits the calling of special election at any time for the submission of water bonds to the voters.

Terms of Municipal Bonds

With the amount of bonds determined, the next step is to arrange what we call the "set-up" of the issue, meaning the maturity, provisions for payment, rate of interest, etc. Modern practice has demonstrated that there are recognized principles of sound finance which should be applied to municipal affairs as well as to private business as far as possible. I believe the greatest evil in arranging municipal bond issues has been the tendency to postpone for too great a period the payment of the debt. In the matter of the maturity of municipal bonds and

the method in which they are paid there has been much progress. The best thought on the subject of municipal finance requires that the term of a bond issue shall not exceed the life of the improvement, so that the burden of the improvement will not have to be borne by people who do not enjoy its benefits. In some of the eastern states where new bond laws have been enacted in recent years, provision is made that the maximum life of the bonds shall not exceed the life of the improvement, such life to be determined in some cases by statute and in others by the certificate of an official such as the city engineer. In arranging the manner of paying these debts, we have come to appreciate the great advantage of the serial or installment bond, as opposed to the old sinking fund bond. In the case of a serial bond issue no sinking fund, with its attendant possible abuses, is necessary, as provision is made each year for the exact amount of bonds maturing that year. As the principal of a serial bond issue is paid the interest is reduced each year the full amount of such payment, whereas, if the same amount of money were credited to a sinking fund it could probably not be invested to draw as much interest as the bonds carry. There are two plans of serial payment, one is to arrange a bond issue to mature in substantially equal amounts through a given period of years. Under this plan the heaviest charge for debt service comes at the start. The second is what we call the "level tax plan" where the amount of principal due is increased periodically as the interest is reduced.

Theoretically a correctly arranged municipal bond issue should be paid in serial installments starting at the time the bonds are issued or very shortly thereafter and continuing through a reasonable life of the improvement. The laws under which waterworks bonds are issued in the three states we are considering were all passed a number of years ago before much consideration or thought was being given to these principles and in operating under them we find ourselves rather seriously handicapped.

The Colorado law, for instance, requires a water bond issue to be paid off within 15 years, but does not permit any of the bonds to be due in less than 10 years and does not require any provision for a sinking fund during the first 10 years. The Wyoming law provides for bonds running 30 years, but optional at the end of 15 years. It does not require any provision for the payment during the first 15 years. The New Mexico statutes allow a maximum maturity of 50 years, requiring bonds to be optional after 20 years. This statute does permit a serial bond issue so that in New Mexico a bond issue can be arranged as to maturity in accordance with the above principles, but it is not compulsory to do so.

It can be readily seen that under all these laws there is a long period of the best usefulness of the water plant during which time a municipality is not required to make any provision for the payment of the debt. In Colorado, particularly, the maximum maturity of the original bond issue is so short that most waterworks issues are refunded at the end of ten or fifteen years and usually without any reduction in the amount of the issue. The Colorado refunding law, fortunately, contains the benefit of modern experience and it is compulsory that refunding bonds be paid serially. It is to be hoped that these laws will be reenacted in the near future to incorporate the benefits of present day experience and practice.

The rate of interest is best determined by authorizing, when the bonds are voted, the maximum rate allowed by law and then determining the most advantageous rate when the bonds are sold. The next step is the securing of adequate and competent legal advice.

Determining Legality of Bond Issue

Modern practice among bond dealers requires that all bond issues be approved as to legality by a firm of attorneys who are known as experts in this line. Either through the agency of bond houses or by municipalities getting directly in communication with such bond attorneys, their services can be secured for a reasonable fee to direct the procedure for any bond issue. On this point I take the liberty of quoting from a recent editorial from the Bond Buyer, the leading municipal bond journal. Commenting on inquiries they receive as to the advisability of this service, they say:

Invariably our advice is to have a recognized firm of bond attorneys not only write the approving opinion but also supervise the proceedings from the start. A municipal bond issue which does not carry with it the opinion of one of these recognized bond attorneys is not readily

salable and, therefore, the municipal bond dealer must secure this opinion at his own expense, if the issuing municipality has not seen fit to arrange for it prior to the public offering of the issue.

In view of this situation, it follows that dealers bidding competitively for a bond issue, if advertised as carrying the opinion of these recognized attorneys, which opinion is to be paid for by the issuing municipality, will, in effect, add the cost of the opinion to the price which they offer to pay for the bonds, since the payment of the attorney's fee by the municipality clearly relieves them of one of the usual expenses which is incurred in handling a bond issue.

Aside from the simple question of the cost of the opinion it seems to us there are other advantages accruing to a municipality which arranges in advance of its bond offering for the favorable opinion of a municipal bond attorney.

First, to have the proceedings leading up to an issue supervised by one of these bond legal experts virtually precludes the chance of making some technical error that might invalidate the issue and lead to repassage of ordinances and resubmission of an issue to the voters, readvertising of an offering of bonds or some other duplication of effort and expense.

Secondly, when the prospective buyers of an issue are assured that the favorable opinion of a recognized municipal bond attorney has been arranged for in advance, the dealer is assured that upon the award of the issue to him there will be no unusual delay in delivery of the bonds resulting from technical legal difficulties. This is most important because the dealer must always consider the possibility of fluctuations in the bond market. Unless he can resell the bonds to his clients quickly, his risk of having the market turn against him is considerable and he must take all of this into consideration in estimating the margin of profit to which he is entitled in handling the bonds.

It will be readily apparent that, particularly in New Mexico, with one bond election possible only once in every two years, a legal error in connection with such an election would be very serious. To my personal knowledge several of the larger cities in all three of these states already employ expert advice whenever they contemplate the issuance of bonds.

Methods of Selling Bonds

When the preparatory work has been done in this way, the sale is a comparatively simple matter. There are two methods of bond sale, namely; public and private. Technically speaking a public sale is a public opening of sealed bids received after advertisement. New Mexico is the only one of the three states requiring by law public advertisement of water bonds. Here notice must be published for thirty days in a New York paper, a Santa Fe paper and a local paper. In Colorado and Wyoming the method of sale is left to the discretion of the municipal officials. In these states very often the sale of the bonds and the securing of proper legal instruction and competent advice as to the set-up of an issue are obtained all in one operation by selling the bonds prior to and subject to the election or authorization. Ample competition is obtainable by a short notice sent to a few houses known to be interested. On the other hand, where greater publicity is desired either the bond attorneys or bond houses are ready and willing to give municipalities the benefit of their knowledge and experience in helping them to prepare correctly a proper set-up for a bond issue.

One of the most common provisions in municipal bond statutes throughout the country is, or more correctly was, a provision requiring the bonds to be sold at not less than par, evidently inserted to prevent municipal officials from making an unfavorable bargain, and it is not uncommon to find both a maximum rate of interest and provision that bonds must be sold at par. This applies both in Wyoming and New Mexico and every now and then a combination of circumstances results in a given municipality not being able to obtain par for bonds carrying the maximum rate of interest. When this condition exists, it is necessary either to hold up the project or evade the law.

Municipalities, without exception, can obtain a cheaper net borrowing rate on their bonds if they will, when permitted by law, sell at a slight discount. This enables the bond house to buy the bonds at a price so that it in turn can sell them to the ultimate investor at par and almost without exception investors will accept a lower rate of interest at par in comparison with a somewhat higher rate when they have to pay a premium.

NEED FOR COMPREHENSIVE COUNTY ROAD PROGRAMS

By J. J. Ermatinger, Editor North Dakota Highway Bulletin

(Editor's Note: While the nations and the states have comprehensive highway development programs, most counties are still developing their roads in a hit or miss fashion. The present article, while written from the North Dakota viewpoint, contains much of value to counties everywhere).

Economy and efficiency are the result of the adoption of a wise and sound plan after a complete and thorough analysis of the problem to be solved, the careful execution of that plan and a constant watchfulness against retrogression or deterioration. This statement is almost axiomatic and applies equally to the building of a home, a business block, a railroad or a public highway. It might well then be asked whether the time has not arrived when counties and especially boards of county commissioners shall give heed to these principles in the construction of county roads and more especially the main county highways to supplement and dovetail with the state highway system. Such highways may also be regarded as main market roads because they bear the heavier burden of local traffic from the farm to the trading center. This statement is not to be construed as a criticism of present methods, nor present county boards. Anyone familiar with their work taken by and large knows what tremendous efforts they have made to serve their constituency well and the many handicaps under which they have labored. But times are changing, new traffic conditions and the growth in road use calls for newer and better methods as well as harder and more forehanded thinking. It is in this spirit that these lines are written.

In recent years, urban dwellers have heard much concerning the need for city planning in order to provide a systematic and scientific scheme for city development. To many, city planning suggests merely civic beautification and park expansion, but to the initiated it means facilitating traffic, house zoning, terminal provision or, in short, the emphasizing of the utilitarian aspects of city growth and securing an orderly and systematic development instead of a hodgepodge of unregulated and unrelated construction. The most notable example in America of city planning is Washington, D. C., which was laid out and built along the lines suggested by the French engineer, L'Enfant. San Francisco, Cleveland and other large cities have given much thought and no little construction on a city plan. Minneapolis' fine park and parkway system was not a haphazard growth, and while primarily a scheme of beautification, recreation and residence district development it has had an important economic bearing on property values.

While the federal aid system of highways in the United States is not a completed plan, nevertheless it adheres largely to the same principles of planning or peconstuction thought. Each highway department has been permitted in a limited degree to determine what shall be the national highways within its respective state. Nevertheless such highways must couple up with those of other commonwealths. State highways have been divided by the national government into a primary system or interstate roads which shall comprise not more than three-sevenths of the entire road mileage of the given state, and secondary highways or inter-county roads. Before any considerable construction was undertaken each state laid out tentative paper roads or routes of necessity so as to settle what roads shall come within the designation of its state highway system or seven per cent system, i. e., constitute 7 per cent of all its roads whether county, township or state. Thus it was necessary to provide some sort of a plan, which we might call state road planning. There was nothing hit or miss about this scheme even though in a measure it is subject to some slight modifications. Two factors were used in fixing national roads, travel and connections with other states. In the county or secondary system, the first endeavor was to connect all county seats and then the more important trade centers with each other. There are 106,202 miles of road in this state of which the State Hightway system is seven per cent, or 7,484 miles and the balance either county or township roads. The last census of roads taken in North Dakota was in 1923 and hence, its data is somewhat antiquated for the purpose of determining what are or are not county roads as no doubt a considerable change has taken place within that time in this respect. For that reason, we must resort to approximation, and therefore, assuming that there are 300 miles of main county highways in each county on the average,

we have a total main county road mileage of 15,900 miles or more than twice that of the State Highway System.

A County Road Plan Is Profitable

If in the pursuit of efficiency and economy, it is wise to have city planning, and if, in the construction of main interstate and intrastate roads, a state highway system is the universally accepted thing, then it may well be questioned whether or not, a similar device woul not only prove profitable but also efficient in the improvement of our main county roads. Certainly, theoretically this has been generally accepted as sound, but the almost universal practice is far wide of the mark. Broadly speaking, road building falls into three major divisions: (1) routing or location of the road; (2) construction, and (3), maintenance or upkeep. In its essentials, routing of the county road in this state is least open to criticism because of necessity the larger centers of trade must be joined by an artery of traffic, but in details there has been some deviation from sound principles. Not always the most direct route has been selected, and in order to hold down first costs in the mistaken notion of economy, roads have become tortuous and every little hill which might result in extra construction costs due to cuts or fills has been avoided. In short, we have not built roads, we have just thrown them down on the surface. This is grievous error because first costs are in the final analysis the lowest; it is construction costs, and reconstruction costs and maintenance expense that mount up into large figures over a period of years. Road locations should be permanent and the shortest route with a few exceptions is the cheapest in the long run, as every mile eliminated in reaching a given point means just that much saved in future construction and maintenance. After these considerations are accepted as guiding principles, it would seem that the test to be applied in selecting the main county roads should be something along these lines: A traffic count to determine which roads serve the most people, i. e., roads which are most used. Such a traffic census should not be just for a day, but for several days, and for different periods of the year. The county should reveal the road burden for different seasons including winter travel. It might be argued that county boards by reason of their knowledge of local conditions can settle this matter without this information. While this may or may not be true, the fact remains that such knowledge is largely impression and as such does not constitute a fact basis which a traffic count will provide. Besides, a traffic count in itself will act as a protection to the county board and disabuse critics that the road has been located as the result of favortism or "pull." It is one thing to be right and another to be able to prove to the doubting Thomases that you are right, and the traffic census is the proof. Another consideration in determining what roads shall be main county roads is whether or not, the roads will connect the leading market centers of the county, and finally, the intercounty connection of these roads with similar highways of neighboring counties. After each county has fixed tentatively what are its main highways, it will be necessary for the county boards of the contiguous counties to meet in joint session and settle the problems of such intercounty connections in order to insure the best results. Some county boards in other states seem to regard the county as their particular satrapy over which it is their privilege to govern with all the prerogatives of Thrasybulus and his thirty tyrants of ancient Athens. But we in America, and North Dakota, know that Thrasybulus and his ilk were driven from Athems in their day and have been dead for these many years. It is our ideal to build so that not only our immediate constituency shall profit from our efforts, but also that indirectly our neighbors shall benefit. In North Dakota, a county is merely an artificial boundary line for local administrative purposes and that its regulation is and should be based on the concept that we are one people whether we reside in Cass or in Golden Valley counties. In brief, we think in terms of North Dakota rather than in terms of our own back yard, and yet that the improvement of our own little plot of land by that much improves the entire commonwealth. Thus, the resultant reaction is co-operation and compromise for the good of the whole state.

Standard Types and Minimum Specifications

After a comprehensive county road system has been outlined on paper first, the improvement should proceed in an orderly sequence, the more important roads to be improved first as it is not suggested that the entire system be brought up to the highest standard as a single act. This means applying the same processes as are employed in state high-

way improvement. It is the only logical and economical policy. The next step would be the adoption of uniform standards for the type of road such as width, grade line and curve tangents. Perhaps this as a matter of practice has already partially developed, but never has been formally adopted. It may be necessary to adopt several standards owing to the diversity in population density and economic sufficiency of the different counties, for it must be patent that a county road in Cass might require different standards than those of a less populous county. For this reason, counties might have to be classified and standards adopted for each class. At any rate, a minimum standard should be adopted for all counties, leaving those more able to provide better highways to do so.

The next step should be the adoption of uniform and standard specifications. This will not only insure uniformity in construction work but will also do much to aid counties in securing many bids for their construction work and so reduce the cost of construction because contractors will be familiar with them and so be more ready to bid on the work knowing exactly what they will be called upon to do. There will also be less room for the play of favoritism by inspecting officers.

Finally, all materials used in construction should be thoroughly tested to ascertain their compliance with the rules laid down. As the State Highway Department maintains a testing laboratory, it can easily perform this service for the counties and with little expense to them. Hence, the specifications should provide for such testing by some central authority which can give an impartial judgment.

To insure full protection to the county, a standard form of contract might also be added to the scheme of uniformity. The best of lawyers often not especially familiar with the special problem overlook essential points in the drafting of contracts or other documents. My personal experience over a number of years has demonstrated the soundness of this suggestion.

How shall standard types of road, standard specifications and standard contract be provided? The first two are engineering duties and the latter a lawyer's domain.

The boards of county commissioners through their state organization can readily agree that all the county surveyors of the state be called together in a meeting and instructed to agree upon these matters. Perhaps, recommended standards might be framed by the State Highway Department as a basis for this gathering to work upon as it is apprehended that some counties do not employ technical men. This suggestion is founded on several requests received by the Highway Department for such standard types from a number of counties. Next, it may be possible to enlist the office of Attorney General in connection with the county attorneys to promulgate standard forms of contracts and bonds.

Proper Construction Supervision

Thus far we have been dealing with paper propositions, but when actual construction commences then the real problems present themselves. Every base ball game needs an umpire to insure compliance with the rules of the game and to make decisions. But in the big leagues even the umpires are subject to a limited supervision by the president of the league to insure their being good umpires. In the construction of county highway, let us take a leaf from Uncle Sam's methods in the building of federal aid roads. Before federal aid is granted, the Bureau of Public Roads must approve the location of the road, likewise, the type of road, the specifications, etc. Before any road is accepted, federal engineers make certain that the whole has been done in accordance with the contract and other regulations. Again, the state must agree to maintain this highway up to a definite standard. This supervision is predicated on the basis of uniformity for highways throughout the country, the full compliance with all agreements and to prevent deterioration after building. Any one familiar with the whole plan and the motives behind it will agree that it is based on sound and economical principles.

No doubt some such similar regulation over the counties would prove salutary. It is not that the counties as a general rule would not religiously follow the rules of the uniform agreement or standards, but this supervision would provide double assurance that each and every one was doing so. A policeman does not arrest all good citizens because nearly all obey the rules of the government, nevertheless he is also a protector of the good citizen and a deterrent force. It is possible for the boards of county commissioners to create such a supervising central body of their own or ask the legislature to do so. On the other hand, this loose form of supervision could also be vested in the State Highway Commission

as an existing and functioning organization.

Constant Maintenance Important

No matter how well laid out a road may be, nor how excellently it may be built, unless the forces of deterioration are arrested, the investment is a degree of extravagance. Consequently, road maintenance is fully as important, if not more necessary, than construction. It is probably in this field that the smaller units of government have been most remiss. Maintenance has been haphazard, intermittent, and withal inefficient; it is the most wasteful and extravagant of road work due to local influences largely. We are not speaking of North Dakota alone but of every other state in the Union. Uncle Sam in his federal aid requirements was not unmindful of this situation when he compelled states by agreement to maintain state highways up to a fixed standard and failure to do so entails the withholding of future federal aid. That is the club which he wields over the state. Cannot the same principle be applied to the counties of the individual states? But where can a club be found, if we agree to this proposition in principle? The answer is already at hand, for each county receives about one-half of the auto license fees emanating from that county. Failure to comply with the rules of the game laid down by the boards of county commissioners jointly should and could result in withholding this portion of the license money and redistributing the same to the counties which play the game fairly. That is what Uncle Sam does and why not the Flickertail state?

County Planning Not New

County planning of county roads is not a novel suggestion. Our own state seemed to have something like this in mind when Chapter 110, Laws of 1915, was passed creating boards of highway improvement for counties. It has also been a moot question informally discussed here for years. Other states are agitating the same idea, while some already have it in actual use though under another form. Allusion is made to so-called state aid roads separate and distinct from the federal aid roads of those commonwealths. Wisconsin, which probably was a pioneer in this field, offers a good example of county road planning and we quote a recent article on Wisconsin roads:

"'The Wisconsin Idea—A Good Road to Every Farm.' This means that Wisconsin is improving every road within its borders. The improvement of the Wisconsin highway is not onesided, but symmetrical, the harmonious betterment of its part. * * *

"The counties of the state have voluntarily selected ten thousand miles more of their main roads as county trunk highways and maintained them effectively. Approximately twenty-thousand miles of its total of seventy-eight thousand miles are patroled and ninety-eight per cent of the population live within less than three miles of a patroled road. Approximately twenty-nine thousand miles are surfaced.

"The first State Aid Law of 1917 provided for the improvement of specified portions of a county system of highways, initiated by the local unit, constructed by the county and supervised by the state. During the first six years of operation under this system about five thousand miles of roads were improved, but because these improvements were initiated locally and designed for local purposes there was no co-ordinated state system * * * Provision for such a system was made in the State Trunk Highway law of 1917 * * * The benefits resulting from the maintenance, marking, and signing of the State Trunk System were so immediately apparent that the Legislature of 1919 authorized the system to be increased to seventy-five hundred miles, and the Legislature of 1923 authorized a further increase of ten thousand miles which is the present system."

No doubt similar examples can be cited from the experience of other states.

It is not our purpose to advise what the county officers shall do, much less endeavor to dictate, but it is our sincere hope that the county commissioners themselves will initiate these steps and if deemed desirable make them effective through proper and well-planned legislation. If we should succeed in crystallizing sentiment and desultory discussion into active measures which will result in an economical and well-planned county system of county highways and constructed and maintained on a high basis, we shall have realized our goal in the submission of these reflections.

DEVELOPMENTS IN METHODS OF SEWAGE DISPOSAL

By C. G. Gillespie, Director, Bureau of Sanitary Engineering, California State Board of Health, Sacramento, Calif.

(A paper read on Aug. 16, 1926, before the annual convention of the League of

California Municipalities).

Even to one who is almost hourly in touch with sewage disposal, events are coming on with bewildering rapidity. Looking back from our present eminence, only the last few years seem to have been productive; yet, as a matter of fact, the rudimentary principles were established in the '80's and '90's by scientists whose work we may incline to forget. That was the time when men first really learned of the teeming micro-organisms of the earth. Scientists in the sewage disposal field shortly deduced that sewage oxidation was the work of micro-organisms living in an aerobic environment, and that sludge digestion was an anaerobic process. They sensed somewhat that the different groups of micro-organisms were influenced by their physical and chemical environment, by food supply and antagonistic population. Even today we barely more than sense these truths. In our mechanical age we have made principal progress in the mechanics of sewage disposal and treatment, rather than in the far more potent field of the sciences.

Yet, to show how far we have advanced, do you know that in 1850 and 1860 serious debate raged, among those indelicate enough to broach the subject, over dry and water-flush toilets, and a bit later, over manholes in streets? About 1852 the cholera outbreak of the mid-nineteenth century ran its course slowly on account of the general state of insanitation of that period. Sanitary sewers were plainly a necessity. First, however, engineers had to develop the art of sewer design from almost zero knowledge in that field. Many still living can recall those badly laid pioneer English sewers. For example, the early sewers were not laid to straight lines but followed the curves of the streets, and had no manholes. We would not think of such a job today. Sewers in this country followed those in England a generation later and there is less of early errors. But now and then one hears of the inheritance of the blunders of the past even in so simple an engineering undertaking as sewers. The youth of the art of sewage treatment may therefore excuse some of its mistakes.

Up to 1854, the General Board of Health in England held it to be unhealthful to spread sewage or even water on ground near buildings. Even before this, streams and tidal waters were commonly intolerable due to the running of cesspool overflow and filth into them. It became a period of great use of chemical disinfectants to arrest decomposition until the substance had been carried beyond the neighborhood. Carbolic acid, chloride of lime, and the like, were used in vast quantity.

About 1860, the claims for manurial values of sewage came along. In England alone sixty towns tried irrigation in rather a blundering way. There was soon a clashing of sanitary and economic interests, the same as we experience today. Farms had been selected without regard to requisite size, porosity of the soil, topography or isolation. They became sewage-sick. The necessary acreage of proper soil was found often to be simply not available.

In 1868, a special commission was appointed in England to investigate the whole subject. Smaller scale but truly scientific experiments were carried on to determine the advantage of intermittent application of the sewage to land. The underlying theory was that the soil should be allowed to "breathe" and thus escape souring. It was noted that dissolved organic substance in the sewage liquid was thereby removed. The investigators did not then know that the principle was not one of atmospheric oxidation directly, but the establishment of conditions favorable to the multiplication of micro-organisms which in turn consumed or broke down the sewage, like worms digesting a polluted soil. The tests told them there was a nitrification, that is, the conversion of organic nitrogen to stable nitrates. It remained for Pasteur and others in the early '70's to show that nitrification simply could not proceed without the presence of microscopic life. This was a fundamental principle.

In 1886, Massachusetts, foremost in industrial activity, perceived that in this country sewers and trade wastes would lead to the same nuisance and river conditions being combatted in England. Accordingly in that year the State Board of Health established the Lawrence Experiment Station. The Station has been operating ever since, turning out research of infinite value to Massachusetts and to the whole country.

Massachusetts is geologically a glacial drift. The aim of the first investigators was to filter sewage at higher rates than on sewer farms through this porous media in more compact areas—the same aim we have today. They established a number of principles correlating pore

space, sewage loadings and rest periods. Many communities in Massachusetts adopted these principles within the next few years. Exceedingly good effluents were and are obtained. Odor nuisance, however, must be reckoned with. The area needed was about half that previously used with land disposal. This was quite an advance.

Striving for still higher rates of operation, coarser grained filters were tried. However, the passage of the sewage through them was too rapid for noticeable improvement. This led logically to the idea of water-tight basins filled with stone, to hold back the sewage at will. Thus was the contact bed idea evolved, together with the establishment of a working cycle of its operation—so many hours in which the bed stood empty to rejuvenate, so many minutes to fill, and then so many minutes of contact after which the sewage was discharged as a considerably purified sewage. A single contact did not effect a material oxidation or noticeable improvement. Double and even treble contact was therefore developed. The size of plant was about one-seventh that of the intermittent sand filters, and one-fifteenth of the sewer farms.

In a short space of time in the '80's, over 40 towns in England took up the system. Our own country was not yet ready for sewers nor sewage disposal and there are but few installations here. We have five in California but I know of none that is a credit. Clogging of the pores of the stone proved to be serious. When less than 20 percent of voids remain, the efficiency is low. A more compact plant, less subject to clogging, was soon to follow. Nowadays that contact bed is seldom considered except possibly for institutional use. The beds can be filled from below and thus can be made fairly free of the fly and nuisance problems of most other processes.

A side development of the intermittent sand filters and contact beds was started by the Massachusetts State Board of Health about 1890. The outcome was the sprinkling filter. This plant evolved from the effort to keep a continuous flow through the filter media. To show the tack along which investigators sometimes go astray, the first filters were coated with a layer of fine material to retard the downward flow. It did not seem possible to them that in the few moments in which the sewage would travel from top to bottom purification could occur. The fine cover, however, arrested air circulation and was dispensed with.

Without reciting the several intermediate steps, sprinkling filters were shortly perfected to the state in which we still build them. The settled sewage is applied to them more or less continuously, in drops like rain. Falling evenly upon the coarse rock bed, it percolates downward in thin films over the stone and thence out through humus tanks as a sewage practically free from putrescible substance. The stones are simply the workshops to which cling literally billions of aerobic microscopic organisms. So numerous are they that the stones are slimed over by them and their effluvia. The slime and the sewage-consuming organimsms are the agents of the sewage oxidation. Provided the sewage stream does not carry more food supply than can be consumed, or, let us say, provided there is the right relation between sewage and the appropriate microscopic population, an oxidation is accomplished in a few moments, which days of atmospheric oxidation could not achieve. The slime also physically enmeshes the foreign matter in the water. The living organisms are like the spider destroying the fly caught in its web.

Whenever the biologic activity is especially intense, as for instance in a spell of warm weather, a part of the slime coating unloads as humus, a rather granular sludge, easily settled and normally free of odor. Therefore a complete plant embodies a final settling tank. The increased rate of purification resulting in these sprinkling filters permitted a plant only half the size of the contact bed or about one-seventieth the size of the old-time sewer farms. The sprinkling filter is still an exceedingly economical sewage oxidizing device.

When supplemented with final humus tanks, these filters produce a good-looking, non-putrescible effluent, easily chlorinated, and they require little attention. Barring certain trade wastes, clogging and overloading is not serious. A few sprinkling filters are still operating with the same stone put in them 25 years ago. Their worst drawbacks are "nozzle nuisance," sending odors into the air around the plant, and the propagation of small flies. Thus isolation is sometimes an insurmountable obstacle. Even small plants receiving a fresh sewage should have fully 1,000 ft. of isolation. Larger plants with more septic sewage may smell for three or four thousand feet.

Sprinkling filters still remain in considerable favor where isolation is possible. Flooding the filter occasionally has been tried to kill the flies. There are some 18 of them in California, operated in most cases with a good deal of satisfaction. It is opportune to remark here on the disaster trade wastes may bring. One of these filters is an utter failure because of a whey load not figured on, and another is an equal failure whenever the cannery in that town operates.

Recently the odor problem with sprinkling filters has been minimized by pre-aeration of sewage ahead of the filter as at Birmingham and Decatur. At both places the loading could be trebled, as a result of the pre-aeration. Los Gatos has recently inaugurated upward ventilation induced by the draft of burning its Imhoff tank gases. The loadings are nearly four times normal, and good results are obtained, except during the cannery season. The filter at Los Gatos is housed over.

We shall here retrace our steps a few years, because sewage treatment splits itself into two main parts. There is the putrescent liquid and there is the putrescent sludge. So far we have traced the work of evolving an odor-free effluent, up to about the year 1910.

Naturally the solids in the sewage have from the very beginning made difficulties, at least of a mechanical nature. They choked land, sand filters and coarse filters. Besides, the sludge was highly obnoxious and bulky. Chemical treatment, by its nature, interfered with biologic treatment and with manurial values. It only arrested decomposition. When its effect was passed, a vastly increased volume of vile sewage was left on hand. Preparatory to land disposal, gullets and ditches were constructed to catch the settlings. As they filled, others were dug. At last accounts, we had an illustration of this ancient practice in the City of Colton, California. Bar screens were also used commonly. They were, of course, crude and imperfect.

In 1890 slude disposal had impressed itself as the major unsolved problem of sewage disposal. It is so today. All other problems are child's play compared to this one . As was appropriate, investigators were seeking to apply newly acquired familiarity with the microscopic world to the digestion of sludge. It was the theory that a certain anaerobic group termed "Liquefiers" would destroy the slude as such. In 1895, Cameron, Engineer of Exeter, England, designed and built a septic tank embodying the theories. The word is now the layman's generic name for sewage disposal. Aerobic organisms accomplish their object quickly. Anaerobic decomposition is very slow. It takes a month or more to complete it in the liquid state and four to six months in the sludge state. Therefore features of the tank where its large size and holding power, whereby the sewage solids had time to deposit and digest, its trapped inlet and outlet, and dark, anaerobic conditions more to the liking and efficient workings of the sludge population. The latter conditions obtain automatically in septic tanks. Thus roofing is more a matter of odor control than biologic necessity.

Patents both on the process and the apparatus were taken out abroad and in this country. You are all aware of the improvident claims made for the septic process. To this day we suffer from the ill-advised propaganda. Perhaps its advocates were misunderstood. In the first place, the liquefacation was not at all fully realized and the sludge to be cleaned out was as rank or more rank than before. The effluent was usually dark colored, highly odorous and pathogenically dangerous. Literally thousands of these tanks, with modifications, have been installed by cities all over the world. There are 85 of them in California communities, and thousands of smaller ones. Notwithstanding their general failure, there is frequently a use to which those now existing can be put, since the advent of separate sludge digestion and the activated sludge process. By reason of their simplicity they are still unreplaced for rural and for many resort and institutional sewage treatment problems.

About 1908, Travis of England conceived the plan of keeping the effluent of the tank fresh for biologic reasons and sought a separate sludge compartment for its digestion. Mr. Travis thought, however, that sludge digestion required a certain amount of new sewage liquid and so devised a two-story type of tank by which he could turn a part of the sewage flow through the lower or sludge compartment. In addition, he provided what he called "colloiders" in the upper chamber, resembling upright slats. He expected that the milky colloids of the sewage would become attached to the colloiders and gradually slide into the lower compartment. His premise thus was that sewage clarification was a physical phe-

nomenon. So far as we know, there are no actual installations of the Travis tank.

In 1909, Dr. Imhoff in Germany designed a modified Travis tank without the colloiders and without the passage of liquid sewage through the sludge chamber. Overlapping walls formed a trap to prevent the return of gas buoyed sludge to the settling chamber. The object was to clarify the sewage sufficiently rapidly that a fresh effluent would obtain and sludge digestion could be an independent process. The process, however, is merely a premiliminary one. It does not pretend to produce an odor-free effluent.

The tank was widely installed in Germany. Patents, now expired, were taken out in this country in 1909. Coming at a time when engineers and public officials were sorely pressed by septic tank litigation, the Imhoff tank was a refreshing substitute. Sixty-eight of them, or nearly as many as of the septic tanks, have been built in California.

The Imhoff tank, too, was put forth with too much optimism, or it might be better to say, with too little regard for the idiosyncrasies of sewage. German sewage and German experiences were frequently not duplicated here. The experience there indicated the sludge would be only about 85 percent water. Experience here has frequently shown it to be as high as 95 per cent water. That percentage difference may seem trifling but it means three times as bulky a sludge. Sludge compartments, therefore, proved inadequate. The fresh sewage striven for can only seldom be realized; first, because the incoming sewage itself is generally stale, and second, because it is next to impossible to keep the surface of the tank free of septic coatings. It is rare, however, that the sludge after digestion is not excellent. It has no bad odor and drains easily. On the other hand, it sometimes digests with such sewage gas ebullition that the gas vents, which the tanks provide, even overflow their walls, to the great aggravation of the operator. Sometimes all the sludge is gas-buoyed to the surface.

In recent years these tanks have been designed with far more liberal sludge storage capacities and larger gas vents. It follows that it is easier to keep a more liberal head-room between the sludge trap and the sludge. The sludge therefore spreads more evenly over the surface. In consequence fermentation is less active. Such departures have been of great benefit.

In two of three Imhoff tanks in this country, mechanical devices have been installed in the scum chambers to drive gas out of the sludge and allow the latter to resettle. Water agitation with a fire hose stream is being used increasingly in this state, and no doubt elsewhere.

The New Jersey Experiment Station has for several years been working to learn the course of digestion in Imhoff tanks and the relation of biologic, temperature and other environmental conditions to tank performance. The first stages of sludge digestion are found to be strongly acid-producing. Sewage containing such carbonaceous matter, such as our cannery wastes, is especially conducive to acid production. In ripe sludge the condition is strongly alkaline. If there is a proper balance between the two, the reaction is favorable for most rapid digestion and no foaming. The Station found that the ripe sludge should amount to 10 per cent of the digesting sludge for a right balance. This would imply a danger in drawing off too much or too little sludge or drawing off too infrequently. If the acid condition prevails the digestion is slow, the tank smells and foams badly. The correct reaction is slightly alkaline, as shown by tests for the Ph value, or hydrogen-ion concentration. At Plainfield, N. J., where the experiments are carried on, it is necessary to add 3 to 25 lbs. of lime daily, to neutralize acidity. Digestion then takes place in half the time otherwise necessary. Digestion was about twice as rapid in summer as in winter.

They repeatedly observed that when gas ebullition is active, protozoa, that is, animal organisms, are in the ascendency and bacterial life declines. In the activated sludge progess Dr. Fowler finds that the filamentous bacteria are in the ascendency when the sludge is bulky. Dr. Fowler has tried to manipulate the fauna and flora, and has had success with differential antiseptic dyes, particularly oxazine. We sorely need more work of scientists in the biological and chemical fields in all our sewage treatment problems. Progress in the New Jersey Station lends the belief that before long sludge digestion can be speeded up materially and thereby effect economies in sludge digestions.

In Germany, the value of the gases evolved has led to trapping them and selling to gas plants. On a non-commercial scale, gas is trapped at Atlanta, Georgia, and even at our own Town of

Los Gatos. At the latter plant, the object of collecting the gas was to reduce sewage odors in the neighborhood. A still further advantage was taken of a situation there, as heretofore mentioned, to ventilate the sprinkling filter through the stack, thus burning all the gas and circulating air upward through the filter. Air is refreshed in the bed every 3.5 minutes, equivalent to one cubic foot of air per gallon of sewage. Whether or not the ventilation is the explanation, a good effluent has been obtained with loadings nearly four times normal.

The operating difficulties of Imhoff tanks gave quite an impetus to fine-mesh screens about 1912. The main developments in this direction have been to perfect the mechanism for ease in removing the screenings and for longer life of the equipment. There are band screens, disc screens, and now drum screens. All of them have a mesh opening 1/32 to 1/8 in., at the choice of the purchaser. The common size is 1/16 in. by 2 ins. long. The field of usefulness of fine screens is as a preparatory treatment, as with salt water outfalls and ahead of other higher grade processes. They remove particles coarser than their openings containing 70 to 85 per cent water. They also take out the coarse, stringy and floating substances from sewage, which in the case of ocean outfalls are easily wind-blown, and in the case of sewage processes, are aggravating to the operator.

The screenings amount to 10 to 30 cu. ft. per million gallons, depending upon the condition of the sewage and trade wastes. In small plants the volume of screenings is trifling and it may be buried or digested. In larger plants, burial is not practicable. New York has a 36 m. g. d. screening plant for one portion of Manhattan. Screenings are to be barged to sea. Milwaukee and Indianapolis find that screenings dried and pressed have scarcely any value as fertilizer. If digested, it has about one-third more manurial value than activated sludge. Milwaukee therefore proposes to cook the screenings under a steam pressure of 125 lbs. for one-half to three-quarters hour, then to digest and dewater in vacuum for five or six hours to a ten per cent moisture basis, at which it contains about 7.5 per cent of nitrogen as ammonia, worth about $12 or more per ton. This method has been used at the Blackwell Island, N. Y., screening plant.

The foaming experience with Imhoff tanks has also resulted in the devising of separate sludge digestion. This process, too, is simply a preliminary one for removal of settleable solids. The sewage is settled in tanks for that purpose and the settlings are transferred to a tank in which they digest. Many of the Imhoff tanks in Germany have been outgrown through the neglect to extend them during the war. The separate sludge digestion has been applied to them as a cheap way to gain the capacity which is lacking.

Separate sludge digestion has the advantage that shallow tanks can be used and turbulent sludge digestion does not disturb the whole process. On the other hand, the sludge must be transferred daily or more often or it starts active decomposition in the primary tank.

We shall now revert to the year 1910 and retrace efforts at the dual treatment of both sewage and sludge through the activated sludge process. No other process has even approached this one in fascination. Effluents are clear, free of odor, and easily disinfected. The sludge produced has a higher manurial value than any heretofore. There is scarcely any odor around the plant. The investment cost is moderate. The cost of operation, however, is higher than we are accustomed to pay.

Leaving aside sludge disposal on land, the activated sludge process represents a further advance in compactness. Rate of treatment per acre is about eight times that on a sprinkling filter.

The process is being tried out in practically every civilized country in the world. The capital outlay for activated sludge plants in Great Britain is about $5,000,000, serving around 1,000,000 people. Numerous cities are carrying on highly commendable investigations, to adapt the process to their paticular conditions. In this country there are some 55 plants embodying the principle. Our pioneer plants are at Houston, Texas, completed in 1917 and 1918. Including experiment costs, Milwaukee has invested about $8,000,000 for a plant to handle 85 m. g. d. The population is 500,000. Chicago has completed its Des Plaines Activated Sludge Plant to serve over 100,000 population. In about two years it will complete the largest activated sludge plant ever built, to serve 1,450,000. The Indianapolis plant has a capacity of 60,000,000 gals. per day, serving perhaps 400,000 people. All of these plants resorted to investigation and re-

search of a high order before entering upon the main program. Chicago has spent over $500,000 to date on experimentation alone. Milwaukee has carried on expensive and elborate investigation for every phase of the design.

California has four of these plants in successful operation now, at Folsom Prison, Pasadena, Lodi and Pomona. Our largest is at Pasadena, serving about 100,000 people. The Folsom plant, one of the earliest in this country, was planned by our Bureau in 1917. Pomona only recently completed its plant to serve 20,000 people. A very small plant for Mountain Ranch School for Boys at Los Gatos is under construction. The population there is 200. A small plant was built in Verdugo Canyon, Glendale, about four years ago, but was never put into use as main sewers reached the canyon before they were expected. One constructed in 1920 or 1921 at Turlock, California, was not a success, probably because of a very heavy cannery load not allowed for. Tulare, California, installed one in 1925 but it has been disappointing, evidently because the sewage is a strong dairy waste and allowance was not made for it. The Pasadena, Lodi and Pomona plants have set a new mark in sewage disposal in this state.

Paris is experimenting with the activated sluge process. In Germany, likewise, the process is still in the experimental stage. There are two plants in Denmark, one in India, one in Shanghai, China, with two more projected. These plants also were predicated on experiment and trial. Canada has at least eight plants in regular operation, one being a plant built as early as 1915. Most of the Canadian plants are small town and city plants, with disposal of sludge by digestion in nearby septic tanks.

A commission for the study of sewage disposal in Moscow finds that the activated sludge process is effective there, but requires 40 or 50 volumes of air per volume of sewage. The commission has also experimented with the artificial aeration of contact filters from below, and finds it can get improved results with an air consumption equal to 2 to 4 volumes per volume of sewage with a pressure of only .01 atmosphere.

It seems the foundation experiments of the activated sludge process were carried on by the Lawrence Experiment Station in 1912-13, reporting superior results after some weeks of aeration. Thereafter activation was eestablished and the same results were gotten in a few hours. Fowler, a well-known English authority in sewage disposal, saw the possibilities and took the idea back to England. Numerous workers there and in this country have pursued the idea to a highly satisfactory position today.

The essence of the process is the conversion of the sludge to an aerobic condition by constant but gentle air agitation. The sludge particles then become the workshop of the myriads of biologic forms essential to sewage purification, which we first observed in the sprinkling filter slimes. In the present case, the biologic population lies in the sludge and is brought to the sewage through the medium of the agitation. As in intermittent sand filtrations and sewage farming, the nitrifying organisms must be kept alive or the process suffers. If the conditions relapse to the septic state, the nitrifying organisms die completely, just as a plant in a sewage-sick soil. In fact, a growing plant suspended in an activated sludge tank is a good barometer of its condition.

However, the process is far from the delicate, inelastic one that it first appeared. It has been adapted to some refractory wastes. Experiment gradually tends to show its wider and wider applicability to miscellaneous waste if only the conditions are known and allowed for. The process can stand considerable shock and rough usage. Force of circumstances has compelled the shutdown of several of these plants for hours, or even days, with no harm. The plant at Bury, England, is shut down at night regularly. The plant at Lodi is shut down in the evening hours of heavy lighting load, except when the cannery is running. At that season continuous operation is necessary. The crux of the matter seems to be the amount of reserve biologic force on hand at the time of shutdown. On the other hand various trade wastes, as from tar, oil, wool waste, tannery waste, creameries and canneries, have disorganized the process temporarily or permanently.

By way of brief description, the sewage undergoes air agitation for 4 to 15 hours, depending upon the nature of the sewage, in one or more tanks containing from 10 to 35 per cent of previously activated sludge. Both sewage and sludge circulate together through the tanks continuously, barring shutdowns. The necessary time of aeration and sludge present is a matter of adjustment of sewage supply to

the microscopic population which consumes it as was the case with the sprinkling filter. The exact amount of air, time of aeration and per cent of sludge required are not yet so precise but that it pays to establish them in each instance before designs are made.

To free the effluent from its sludge load, the outgoing sewage is passed through one or more settling tanks holding 1½ to 3 hours' flow. The sludge settling there is light and curd-like, settled quickly, and precipitates with it everything but clear water. The deposited activated sludge must be withdrawn before septicization sets in. It is revived if necessary by re-aeration, and then passed through the process again as the nucleus for the improvement of new incoming sewage. From time to time the surplus sludge must be gotten rid of. As it varies from 98 to well above 99 per cent of water, its volume amounts to 10 to 15 thousand gallons per million gallons of sewage.

Progress in the process is in three main directions: establishment of the air, sludge, aeration and re-aeration requirements over a wide range of sewages; economic aeration with agitation, and developing manurial values from the sludge.

Various types of plant have resulted from the endeavor to economize an aeration and power consumed. There is now the use of air diffusers which are simply porous plates in the bottom of rectangular basins whose purpose is to break up the bubbles into small particles. Fine air particles are said to be fully three times as effective as coarse. The early tank bottoms were ridge and furrow construction. The later ones are of the Manchester type. They are flat-bottomed with one or two rows of diffuser plates along one side, inducing a spiral motion of the sewage mass. A side development is the search for high efficiency compressors. Then there is bio-aeration, using mechanical paddles in long shallow channels to chop the surface of the sewage. Another variation is mechanical agitation in a Simplex Aerator, a patented device. It comprises the use of high-speed revolving vanes near the surface of the tank center, the sewage being drawn up a central standpipe and whirled by the propeller to entrain the air. Air diffusion of the Manchester type appears to be the most positive of any and probably no higher in power costs for equal results.

There is debate on the need of re-aeration of returned sludge. It is evident that there are cases where it is not necessary. There are other cases where sludges goes septic and it is a great asset to have re-aeration. In experiments carried on in India, remarkable results are claimed by care in proportioning return sludge to the sewage flow and strength. Going back to first principles, this is plausible. Some investigators find that thorough sludge re-aeration accelerates the process and lessens the primary aeration to as low as one hour. It is the part of discretion at this stage of the art to provide for re-aeration, perhaps not at special expense, but by equipping primary aeration tanks for secondary aeration.

Preliminary treatment of some sort is generally considered to be necessary. At Epsom, England, however, sludge was less bulky when preliminary treatment was dispensed with. Fine screen openings at Pasadena was an advantage in that it decreased somewhat the sludge produced in the process.

Settling tanks are being used with good success at Chicago and Indianapolis for the double purpose of preliminary treatment and of digesting anaerobically the spent sludge of the entire process. Experimentally, good results have been obtained in the same manner by Dr. Imhoff in Germany. The high fluidity of activated sludge requires a very much greater sludge storage capacity than the present Imhoff tanks, perhaps three or four times. A heavy gas formation and rapid digestion are obtained. Some have suggested the use of the gas for power. Pomona was the first city in this state actually to install this mode of sludge handling on a working scale, guided by the Chicago experiments.

The sludge produced is highly fluid and holds tenaciously to its water. Various methods of handling it are in use. Those who know agree that a good sludge, easy to de-water, requires a good effluent. In small plants the sludge is digested anaerobically in septic tanks, as in the Canadian plants referred to.

On the continent and at Houston, Texas, the sludge is lagooned in ponds, apparently without offense. The Houston ponds amount to 1.5 acres for a 5 m. g. d. plant. At Pasadena, lagooning to a depth of about 18 ins. led to intolerable nuisance. However, as this occurred early in the operations, the poor condition of the sludge may have had something to do with it.

In a number of places wet sludge is

run by itself, or diluted with effluent, onto land for fertilizer. This disposal is sometimes used at Lodi, Macclesfield, England, runs the sludge onto a 10-acre farm and obtains a $5,000 return from it. However, according to Mr. Hatton, chief engineer of the Milwaukee plant, there is less than half as much fertilizer in wet as in dried sludge, and of course freshly produced wet sludge has a use limited to coarse crops. It is apt to be pathogenically dangerous. Digested or dried sludge, dehydrated to 10 per cent moisture, does not have this limitation.

Small plants may resort to drainage upon sludge beds. Lodi uses this method at times. About three acres are sufficient for that community. In a couple of week's time, 3 to 4 ins. of wet sludge can be raked off the beds as dry flakes. In damp weather the beds have tended to sour to some extent.

Because it represents an intensive effort at a high degree of sewage reclamation, the work of Milwaukee, Chicago and Houston, and I believe New Britain, Conn., in sludge drying, may be epoch making. For that reason considerable space will be devoted to it. Since tankage of slaughter houses has been turned ot the making of stock and chicken feed, the fertilizer industry needs organic nitrogen, which only sewage can supply. Milwaukee produces approximately 1½ tons dry sludge per million gallons of sewage, containing 7.5 per cent organic nitrogen and selling around $15 per ton in large lots. This more than covers the cost of preparing the sludge.

The fertilizer is used for lawns and any kind of crop without danger of burning. Its best market, however, is with other fertilizers to supply what they lack.

To make the sludge attractive for sale, it must be dried to about 10 per cent moisture and pulverized. The actual drying is not a problem. In small plants it is done by exposure to the air. In large plants wet sludge cake is first produced, having not over 80 per cent water, and the cake is then dried in heat driers. to avoid scorching. To prevent balling of the wet sludge, dry sludge in about equal amount is mixed with the wet before drying. After drying it is pulverized.

The de-watering from 98 to 99 per cent down to a cake having 80 per cent or less of water for drying has been the principal problem in sludge reclamation. Sludges have shown great dissimilarity in their response to de-watering operations, and to summer and winter temperatures. The problem is one of conditioning the sludge to give up its water, somewhat like curd gives up its whey. More than a dozen methods and devices have been used, including precipitation, flotation, pressure and vacuum filtering, pressing, air drying, centrifuging, spraying, and mixing with inert earth and garbage. At Milwaukee the procedure has been based on breaking down the colloidal nature of the material by adding acid in sufficient amount to put the sludge in an isoelectric or neutral electric condition. The amount of sulphuric acid used varies from 3.8 to 5.3 c. c. per gallon. In winter even this treatment was inadequate until the sludge after acidification was heated to 120 to 155 degrees Fahrenheit. When so treated the sludge was easily filtered to a thin cake on Oliver cloth filters.

Chicago has succeeded without heating the sludge and gets better results with 4 to to 10 lbs. of aluminum sulphate than with the acid, as used at Milwaukee.

Fertilizer production after these methods is not yet on a full scale basis and actual cost statistics are not available. The sludge is highly valuable but it may take time and education to demonstrate it. Milwaukee is going about it in a businesslike way. A fellowship has been established in the Department of Agriculture of the University of Wisconsin and the commission is a member of the National Fertilizer Association. Demonstration and field experiments are being carried on around Milwaukee on golf courses, farms and gardens. Mr. Hatton, chief engineer, is so sanguine of the ability to handle sludge profitably that he states he would not hesitate at all to advise a community having as low as 1,000,000 to 2,000,000 gals. of sewage per day to go ahead and process their sludge.

England until recently has not tried to perfect the marketability of sludge but does not try to put it to fertilizer use with least expense. The plan upon which Milwaukee, Chicago and other cities are embarking to market the sludge obviously calls for a high degree of good business management.

A wholesome prospect for the firmer establishment of the activated sludge process is that in so many cases recourse has been made to experiment and demonstration on a small scale before undertaking large plants. A review shows that it pays to do this, even in small plants. But in such experiments every important factor must be recognized in the experimentation. It is because of failure to

recognize the variable factors or to take them into account that experimentation has sometimes not tallied with working results.

Right now there is the temptation to cheapen operation down to the quick, where a barely passable effluent is obtained. Conservative engineers contend that the sludge problem is the big problem of the process and that to maintain a good sludge requires a good effluent. At the risk of slowing up the adoption of the process, I believe in this view.

Activated sludge costs are on par with water filtration, that is, approximately two or three cents a thousand gallons for operation and about two cents a thousand gallons for fixed charges, exclusive of revenue. This amounts to a charge of between one and three dollars per person per year. The costs are not high but they are relatively high because we have not been accustomed to pay scarcely anything for sewage disposal. The financial system of our municipalities is not adjusted to the changed order. Rather than cheapen operation, or discard the process, I believe we should go into the business of making money out of sewage. There is profit in the manurial values and in sale of water for irrigation. The water itself is a good fertilizer. The arid West needs all the water it can get. The city of Pomona has already contracted for the sale of its effluent at sixteen cents a miner's inch in summer and nine cents a miner's inch in winter. The average return is a little under one cent per thousand gallons, or about $3.25 per acre foot. Many parts of California pay more than this for straight water. Crops are raised at a profit where irrigation water costs $30 to $50 per acre foot.

ELIMINATION OF RAILROAD GRADE CROSSINGS IN NEW YORK

By Alfred E. Smith, Governor of New York

(Editor's Note: The following article appeared in some of the motor club magazines recently. It tells how and why New York plans to spend $300,000,000 for the elimination of highway-railway grade crossings.)

There is no more important subject in our state having for its purpose the preservation of life than the elimination of railroads crossings at grade. Several of the cities of New York have grown at such a rapid rate that railroad operation at grade through them has become an hourly menace to life.

And it is not a problem that is unique to New York State by any means. Our country is covered by a network of railroads. Wherever there are railroads, there are highway crossings at grade. And it is only trite to remark that the astounding increase in the number of automobiles using the highways of our nation has made the railroad grade crossing a constantly recurring matter of life and death. As the vehicular traffic increases, so does the list of deaths lengthen.

The hit-or-miss policy of the state up to the present in regard to financing the removal of grade crossings has been most deplorable. But little more progress has been made of late than was the annual custom a decade or more ago.

It is a source of gratification, however, that a settled policy has at last been adopted, the soundness of which has already been approved by the voters of the state who stand ready to finance the $300,000,000 bond issue necessary to put through a comprehensive program of grade crossing elimination. This issue, approved at the polls last November, the proceeds of which are to be devoted to removing grade crossings, is the largest sum ever proposed for a single purpose in our state. The program is the most ambitious yet conceived in any state, and the action of the people of New York will, no doubt, be followed by agitation for similar purposes in many of the other states of the union.

It is hardly necessary to indicate the crying need for immediate and decisive action for the removal of the grade crossing menace. During the decade from 1914 to 1924 in New York state there was reported a total of 4,977 accidents at grade crossings, resulting in 1,250 deaths and 3,543 injuries. An almost constant increase in the number of accidents each year of the decade was shown, there being 296 in 1914, the first of the ten years, which increased to 835 in 1924.

We can not avoid responsibility in some measure for this unnecessary waste of human life. And yet, what has been the method of meeting this responsibility in the past? If we were to proceed with grade crossing eliminations in New York State in the same ratio that we have since 1897, during which period the largest number of crossing eliminations in one year has been 36 and the average number four or five, it would take us some 270 years to complete the job, for

we are informed that there are approximately 8,000 grade crossings in New York State, of which about 4,000 are listed as being especially dangerous.

It was the old story of postponing necessary public improvements and living from hand to mouth on the short-sighted policy of making economy records. The primary purpose of the $300,000,000 bond issue was to enable localities and railroads to enter upon a program with the state promptly and immediately and which in a comparatively short space of time would mean complete elimination of these danger spots. Certainly even 20 years is appreciably shorter than 270!

The old procedure of small appropriations and legal difficulties was productive of nothing but delays and the smallest possible percentage of accomplishment. Under the old law, a railroad paid 50 per cent of the cost of any elimination, the municipality 25 per cent and the state 25 per cent. Obviously the state could not proceed unless some of the intermittent appropriations were forthcoming, and then it was the procedure of the Public Service Commission, under which eliminations were effected, to wait until the railroad, the governing officials of a locality or the Public Works Department presented a specific elemination project.

ACCIDENTS AT GRADE CROSSINGS IN NEW YORK

Fiscal Year	Vehicles			Pedestrians			Total		
	A	K	I	A	K	I	A	K	I
1923-24	781	160	535	54	30	26	835	190	561
1922-23	719	91	474	50	29	23	769	120	497
1921-22	439	112	319	43	27	15	482	139	334
1920-21	463	91	370	39	24	15	502	115	385
1919-20	393	79	297	40	15	27	433	94	324
1918-19	371	91	283	55	23	34	426	114	317
1917-18	415	95	322	67	44	27	482	139	349
1916-17	350	79	269	96	53	46	446	132	315
1915-16	229	71	183	77	42	43	306	113	226
1914-15	225	58	195	71	36	40	296	94	235
Total for 10 years	4,385	927	3,247	592	323	296	4,977	1,250	3,543

A—Accidents. K—Killed. I—Injured.

Most of the railroads were in no position to finance such a comprehensive grade crossing elimination plan as was necessary, whether grade crossing eliminations are regarded as a capital or an operating expense. Railroads seem always to have some use for their funds other than grade crossing eliminations.

Similarly, a great many municipalities are face to face with the constitutional debt limit. There was no cure for this situation except in a constitutional amendment to permit the loaning of the state credit to railroads and municipalities so that their share of the cost of eliminations so vitally needed might be financed in the first instance by the state, which would thereafter be repaid in annual installments for interest and sinking funds on the bonds in the same proportion that the railroads and localities contributed to grade crossing elimination. This is what the bond issue amendment of last November authorized.

The law passed by the last legislature setting up the machinery for putting the amendment into effect is explicit. It indicates that the Public Service Commission shall designate the order in which all crossings will be taken up for consideration and a determination made as to the method of elimination. The state's interest and supervision of construction will be conducted through the State Department of Public Works, while the handling of the financial end will fall upon the State Comptroller. Final approval and acceptance of the completed work will be made by the Public Service Commission.

A considerable number of people are under the impression that the ultimate cost to the state for this elimination work will be three hundred million dollars. This is far from true. Of this sum, the state's share and permanent debt will be seventy-five million dollars, while the remaining two hundred and twenty-five million represents the amount the state may temporarily loan at a low rate of interest, if requested, to the railroads and municipalities with which to finance temporarily their share of the work. The principal amount so loaned will be returned to the state in several payments over a period of years, as directed by the state comptroller. The total cost of elimination will continue to be shared fifty per cent by the railroads, twenty-five per cent by the municipalities and twenty-five per cent by the state.

In undertaking a matter of this magnitude, it must necessarily take time to build up suitable organizations competent to handle the work. This applies to the Public Service Commission, the State Department of Public Works and the sev-

eral railroad organizations. The state departments and railroad organizations will proceed to undertake the work with all possible speed consistent with good judgment.

The existing grade crossing situation adjacent to our large cities and their environs is probably as bad as can be found anywhere. The densely populated districts traversed by the railroads and the high value of adjacent real estate make the problems involved in their elimination complex and difficult. It is, therefore, needless to say that under such conditions a more or less general solution must be accepted rather than providing for a few specific eliminations in a hit-or-miss manner. It must be apparent that in cities, villages and elsewhere, a quick determination as to the best way of planning an elimination is no easy task to perform. Isolated railroad grade crossings in open country are entirely different propositions.

Everybody, speaking broadly, is interested in and has a right to be heard in the planning of an elimination at the time public hearings on the case are being held before the Public Service Commission. Representatives of this commission sit in the capacity of a judgeship. When the commission decides that an elimination should be made at a particular place, a notice that a public hearing will be held at a certain time and location is sent to all known interested parties. The principals usually so notified are the State Department of Public Works, the railroad company or companies involved, the public officials of the city, town or village, and all property owners of land adjacent to or directly affected by the proposed elimination, but anyone and everyone is entitled to be heard.

Generally speaking, the more thickly populated is the territory of the elimination the greater the attendance at such hearings and the more difficult the problem is of solution. For example, it is quite evident that if 25 parties are interested in a project for 25 different reasons, the probability is that the whole 25 cannot be brought together on some one plan of elimination. After listening to all the pros and cons and after all attempts at arbitration have failed to bring the differing parties together, the Public Service Commission closes the hearing, or series of hearings as is generally the case. It then considers the testimony and arrives at a verdict in every way similar to a judge in an ordinary court case.

When a decision is reached the commission issues an order declaring how the crossing will be eliminated and directing the Department of Public Works or the railroad, or both, to prepare plans and specifications to carry out the work as ordered. Frequently the largest part of the work of eliminating a crossing in point of time and effort, is used in bringing the project to this stage. In the past a large number of public hearings, covering a period of several months, often years, took place before a final determination was made. It is within the truth to say that the time of actually constructing an elimination project consumed only a small fraction of that taken from the date of the first hearing to the time that the project was actually placed under contract.

To the average layman, protracted delays in advancing a certain project to the construction stage seems entirely unwarranted. Such, however, is not the case. More can be accomplished in the long run by an orderly consideration of the many problems which arise than by hasty or arbitrary rulings, the results of which might cost the state, municipalities and railroad companies large sums of money.

It must be remembered that the Public Service Commission is placed in the position of ordering the expenditure of other people's money. It is, therefore, apparent that whatever plan of elimination is ordered by the commission, it must be the result of the most careful consideration and be judged a justifiable proposition for the money expended.

Naturally, the railroad companies, being heavily involved in the cost of this work, look forward as to what the requirements of the railroad may be 25 years hence. Will the traffic at the point where an elimination is being considered demand a four-track railroad at that time instead of the existing two tracks? If so, the elimination should provide for a four-track system. If a crossing for four tracks is provided, who shall pay the extra cost of the structure over the existing two tracks? Shall it be shared by all parties or should this extra expense be an additional charge for railroad betterment? All such questions arise and must be considered and satisfactorily disposed of.

On the other hand, from a highway viewpoint, it appears that if the alignment of a highway were to be changed somewhat, much more satisfactory and

safe approaches for motor vehicles might be built to a proposed overhead crossing. The change in alignment seems most desirable but unfortunately it will involve the acquisition of new right of way which, after a proper appraisal, would appear to be expensive, and further information reveals that the owner of the property holds its value at twice the appraisal price. Under these conditions, is the changed alignment desirable? Should the element of additional safety in the highway approach be sacrificed on account of excessive costs?

Another problem often presented is whether the elimination should be made by an overhead or underpass structure. An overhead structure, on account of topographical conditions, would require heavy highway grades unless the railroad tracks were depressed, which would involve great expense. Such an overhead crossing might entail extensive adjacent property damage, while an underpass would decrease the property expense and be more desirable as to highway grades. Natural drainage of this underpass, however, might not be possible, and recourse must be had to a pump installation to remove the water which would accumulate at the low point. This machinery would require constant maintenance and supervision, and the annual cost of such for all times to come might justify a much greater expense for a different manner of elimination.

Another objectionable feature, from a highway point of view ,in regard to underpass construction, is the expensive and difficult operation of snow removal made necessary if all year round use of our highways is to be had. The public is demanding more and more that our roads and streets be opened for traffic twelve months in the year and it, therefore, should be the state's policy to avoid conditions which would increase the labor and add expense, on account of snow removal, to our present burden of highway maintenance.

These are samples of typical problems which arise in practically every case. With the bill to be paid by not less than three parties, and often by more, with all primarily interested in getting as much as possible for every dollar expended and with their own particular interests adequately guarded, it is easy to understand that considerable time must be used in study, arbitration and agreements before the several parties harmonize their views to such an extent as to make possible a satisfactory verdict from the Public Service Commission.

The conditions in many sections of our state, especially in proximity to New York City, are such that elimination work must be considered from a broad angle with a look toward the future for a continued growth in population, increase in real estate values and a materially increased traffic both on highways and railroads. The nearness of one village to the surrounding villages, the built-up conditions between them, the large number of relatively unimportant railroad crossings of today which may develop into crossings of prime importance in the future, all tend to make the problem of how and where to start the elimination work under the new referendum act a most complex one.

As soon as the necessary working machinery is set up to cope with the huge amount of work involved in this gigantic undertaking, it will be necessary to consider- first those crossings where the greatest amount of benefit will result from an early elimination. These places will be found on the improved main arteries of travel throughout the state and also in the areas adjacent to the large cities. It is, therefore, needless to state that early consideration will be given the most urgent locations and we hope active operations will be in progress on elimination work during the next construction season. The state has done its part to bring this about, for anticipating the passage of the bond issue, the Department of Public Works has made preliminary surveys and had completed by February first last all other work necessary to present to the Public Service Commission 135 elimination projects.

The Public Service Commission, in turn, has already announced the first list of proposed eliminations, and the program may fairly be said to be actually under way.

USE OF PULVERIZED FUEL IN THE WATER WORKS PLANT

By Charles S. Denman, General Manager, Des Moines Water, Co., Des Moines, Iowa

(A paper read at the 1926 meeting of the American Water Works Association.)

Wonderful progress has been made, within the memory of the writer, in the betterment of our water works methods. This progress has been along lines of engineering, improvement in machinery, boiler room practice and in the purifica-

tion of our water supplies. It is an undoubted fact that within the past five years the modern power station has undergone and is now undergoing an evolution.

The use of pulverized fuel has come into general practice by leaps and bounds not only in Europe, but in the United States. The earliest record of the use of fuel in this form was in England in 1831. Its use has been quite limited, however, until the last ten or fifteen years but is now well known to be past the experimental stage.

In most of our plants it must be conceded that enormous waste exists in thermal efficiency. It has been demonstrated in our plant, which is not a superpower station, that this waste can be overcome and great saving effected by pulverizing the fuel rather than using the ordinary stoker or hand fired installations. The chief advantages briefly are:

Higher thermal efficiency
Wide range of fuel that can be used
Flexibility
Ease of control
Elimination of necessity for banked fires due to enormous furnace volume
Little ash and clinker
Almost complete combustion
Reduction in amount of excess air
Almost absolute control of air supply
Chimney losses reduced
When furnaces are properly operated and designed almost complete elimination of smoke
Lower furnace maintenance costs
Automatic damper and feed control
Saving in labor
Higher boiler rating
Lower necessary capital expenditure for buildings and boilers

Low temperature carbonization of raw bituminous coal at the mines and at the larger power plants is being seriously considered and in some instances is actually in practice. It is the opinion of some writers that we are fast approaching the time when the use of raw coal will practically cease. When this time comes our cities will become healthier and more desirable places in which to live. All of which is along the line of greater efficiency and the elimination of the waste of the valuable by-products of coal.

The ideal fuels for use in pulverizeu form are undoubtedly those of the higher calorific and volatile content and those low in ash. Nevertheless the only question involved in burning pulverized fuel is the price of the fuel. Anything can be burned that has any heat value regardless of the quantity of volatile matter, sulphur, ash, etc. Mine waste is now beginning to be reclaimed and used. In portions of the country low grade lignites are used.

It is stated that in some modern plants steam generation has actually reached 92 to 94 per cent efficiency on short tests, and 90 per cent continuous efficiency. The average plant is probably under 55 per cent efficiency. The average overall thermal efficiency of a hand fired steam boiler at about 55 per cent, when good coal is used, may sometimes be increased to 75 per cent with best conditions and a particularly skillful fireman. Efficiencies of 40 per cent and even less are often recorded on tests. An average of 55 per cent is therfore good normal practice for hand firing.

Modern mechanical stokers, however, give very good reliable results over long periods of operation at or about their rated capacities. The rate of fuel burned per hour cannot be much increased especially where low grade high ash fuel is used.

The class of fuel that can be burned on a mechanical stoker is, to a large extent, limited by the design and adjustment of the stoker.

The average thermal efficiencies on chain grate stokers burning high ash low grade coal is from 55 to 75 per cent.

In November, 1925, we put into operation in connection with one of our boilers at the 21st Street Pumping Station of the city of Des Moines a unit pulverizer which was designed and built by our chief mechanical engineer, George A. Conrath, who was formerly with the Bethlehem Steel Company at the Cambria plant, where he had considerable experience with pulverized fuel. This machine differs in many respects from any other that we know.

The pulverizer has an automatic feeding device which is belt driven from the main shaft of the unit. This shaft is 3½ ins. in diameter with six sets of ordinary low carbon steel rotors. There are six impact hammers on each rotor. The impact hammers are made from tool steel and heat treated to make them very hard. The casing is made in two pieces, from cast iron, an upper and lower half. There are two compartments, one for the pulverizer, the other, somewhat larger in diameter, for the fan. The cast iron casing is lined with corrugated chrome steel

liners. Between each rotor reacting or retarding blades are fastened on the inner liner. The fan is fastened on the same shaft as the impact hammers, thus making the mill a complete unit. The casing is fastened on a bed-plate which is large enough to accommodate a 40 horsepower motor which is directly connected to the shaft of the pulverizer.

The coal is burned as received from the mines without being dried. Although not essential, we think better results can possibly be obtained by drying the coal to a moisture content of from one to five per cent. Dry coal is easier to pulverize and burns more effectively.

A belt type magnetic separator is used for the removal of tramp iron from the coal. As a further precaution in the first stage of the pulverizer there is a tramp iron pocket. The rotor in this compartment is made smaller to give it more clearance so that any tramp iron entering the machine will be driven down into the tramp iron pocket. Tramp iron can then be removed at will, thus not causing any interference with the pulverizer.

About 25 per cent of the air for combustion which is used in the furnace is preheated and admitted with the coal as the feeder. The air which enters the pulverizer casing and the pulverized coal which passes along with it cannot pass directly through the pulverizer casing, but must take an irregular course through it. This is due to the fact that there are no openings provided in the rotors and the slots in the adjacent stationary blade members are arranged in staggered relation. Thus some of the air entering the first compartment passes upwardly around the rotor, through the slots in the lining separating the first and second compartment, down along the rotor and through the opening in the first stationary blade member. The air passing into the second compartment, in order to pass on to the third, must take a lateral zigzag course through the slots of the second stationary blade member or a vertical zigzag course over the second rotor through the second stationary blade opening. In this manner the air is given a drubbing or scrubbing which insures, by the time it reaches the fan, a thorough admixture of air and pulverized fuel. Any coarser particles, which may tend to pass along with the air are retarded by the impact hammers and stationary blading, thus being left behind for further impact to reduce them to the desired pulverized form.

The boilers consist of four 323 h. p. Springfield Cross Drum Water Tube Type with a heating surface of 3230 sq. ft., a superheating surface of 700 sq. ft. and a total heating surface of 3930 sq. ft.

The front wall, back wall and bottom of the furnace are hollow. The furnace contains 2310 cu. ft., which is a volume per rated boiler horsepower of 7.15.

The baffles are of the three pass type with a horizontal baffle on top of the second row of tubes from the rear connecting to the front baffle.

The burner is of the jet type having fan shaped stationary blades for the purpose of throwing a flame of circular or cyclonic effect.

We have made tests from time to time under various operating conditions and on May 13, 1926, an eight hour test was made by our men. The coal was weighed and measurements of the water were taken with a V-Notch meter. This test showed an average boiler efficiency of 81.05 per cent; 6.18 lbs. of water were evaporated per pound of coal consumed as fired. The undried coal was fed from the bunker to the pulverizer.

An aditional economy is eeffected during banked boiler hours due to the fact that banking conditions when operating with pulverized fuel are different from those attained in stoker practice. By stopping the fuel and closing the dampers and auxiliary air inlets the boiler is made similar to a thermos bottle and steam pressure can be held up for several hours. The furnace brickwork having been heated to incandescence during operation gives off a radiant heat which is almost all absorbed by the boiler rather than escaping up the stack. The boiler has actually stood many times for a period of from 12 to 14 hours and then been put back on the line in from 5 to 8 minutes. When it has been off the line also for a long period and become absolutely cold it has been put back into service in 20 minutes.

The coal found in Iowa is one of the lowest grades in the United States. The average B. t. u. per pound of 361 samples as analyzed in our laboratory in 1925 was "as fired" 7998. Three hundred and forty-nine of these samples were Iowa coal, 10 samples were from Franklin County, Illinois, and 2 samples were mixed Iowa and Illinois coal. On the "as fired" basis the above coal had an average ash content of 19.02 per cent, moisture 21.13 per cent and sulphur 4.58 per cent. Under stoker operation the

average per cent of combustible in the ash residue for the year 1925 was 10.23 and the per cent of combustible matter in the refuse material at the base of the stack was 14.40. Compared to this the per cent of combustible in the ash under pulverized fuel operation was 0.6.

We are so thoroughly convinced of the manifest advantages and savings that are being obtained that we have built and are now installing a second unit and, as soon as expert tests are made verifying our expectations, it is our intention to remove the present stokers and convert the plant entirely to the use of pulverized fuel. This second unit is driven by a steam turbine and the exhaust steam from this turbine is to be used in drying the coal.

This method of firing steam boilers has been in use long enough so that there is an enormous amount of available data on the subject of such a favorable nature that there is little of argument left against it. It is our belief that, when the economies and advantages are known, hand firing and stoker operation will, to a great extent, be replaced by this system, because they are a more wasteful method of burning coal. Pulverized fuel is a further step in a policy of efficiency and economy in the conduct of our business and we predict that in a very short time it will be extensively adopted in water plants because of its many advantages which can be so conclusively demonstrated.

ENGINEERS REPORT ON CHICAGO PAVEMENT DESIGN

(From the Journal of the Western Society of Engineers for August, 1926.)

Some time ago Miller McClintock, Director of Traffic Survey of the Chicago Association of Commerce asked for the opinion of engineers regarding certai features of pavement design which have a direct bearing on the traffic-carrying capacity of city streets. A special committee was appointed to draw up some suggestions along that line. The report of that committee follows:

Report of Special Committee on Pavement Design Recommendation Western Society of Engineers

This report was compiled by a committee of engineers, members of the Western Society of Engineers, at the request of the Director of Traffic Survey of the Chicago Association of Commerce. It represents the composite opinion of these members but is not the official opinion of the society. The society is pleased to cooperate in this manner with the Association of Commerce. This committee consisted of L. S. Trainor, district engineer, Portland Cement Association; A. J. Schafmayer, division engineer, Board of Local Improvements, city of Chicago, and F. J. P. Seuel, engineer, Street Department, Commonwealth Edison Company. J. M. Mercer acted as secretary.

Items Considered

This committee drew up an outline of 13 items which it would consider. The outline is as follows:

1. Minimum radius of curb return for different widths of streets.
2. Maximum crown of pavements.
3. Protecting sewer openings, drains, etc.
4. Maximum limits for height of curb.
5. Principles governing the construction of safety zones for street car loading.
6. Practice for safety islands on boulevards.
7. Proper width of traffic lanes.
8. Practice for marking traffic lanes in streets.
9. Markings for safety loading zones.
10. Concave (or center gutter) type of pavement.
11. Practice regarding sidewalk obstructions such as news stands, trash boxes, trolley poles, fire plugs, etc.
12. Practice regarding gutter openings for sidewalk crossings.
13. Use of battered curbs.

The committee reports on the above numbered sub-heads as follows:

1—Radius of Curb Returns

The traffic density and character of traffic are not considered to be as direct a factor influencing the length of radius of the curb return as they are of the width of roadways and of street widths. Hence, in this case the main determining factors are the roadway width and the width of the sidewalk or of the sidewalk and planting space combined.

The need for more roadway space has led to the reduction of sidewalk space to the minimum and the same demand has led to the reduction of sidewalk facilities at intersections by increasing the radius of the curb corner. Practically all students of present traffic needs agree that all space possible should be allotted to the roadway traffic at street intersections. The ruling factor then becomes the space required for pedestrian traffic at intersections. A fair standard appears to be that the sidewalk space of the inter-

section measured at any angle should be at least equal to the width of the sidewalk. This condition would be met exactly by making the radius of the curb corner equal to the width of the walk. Since such a rule would result in a confusing variety of radius length, an effort has been made to establish a standard somewhat approximating these widths.

The following table shows the widths of roadway and sidewalks (including parkway) for various widths of streets:

66-foot Street		80-foot Street		100-foot Street	
Rdy.	Sidewalk	Rdy.	Sidewalk	Rdy.	Sidewalk
30	18	38	21	50	25
38	14	40	20	60	20
40	13	50	15	70	15
48	9	56	12	74	13

Since it is not at all uncommon for streets of various widths to intersect, various combinations can occur. In attempting to meet these various widths, a standard radius of 15 ft. has been adopted in Chicago for normal conditions.

One of the principal factors to be considered in connection with the establishment of standards for radii of curb returns, is the turning axis of motor cars in use today. We are advised that the minimum turning radius of stock cars is about 19 ft. and the majority of the stock cars in use in America today have a turning radius of approximately 25 ft. There can be no question but that the desirable radius for curb returns is one which will permit the car in the lane adjacent to the curb (which is the proper position for the car which is about to make a right-hand turn) to remain in the lane immediately adjacent to the curb until it is in the lane adjacent to the curb of the connecting roadway. The desirable radius of curb returns, therefore, can be set at 25 ft. and from the viewpoint of the user of the roadway, this is a standard which should be adhered to wherever the physical conditions so permit.

It is obvious that such considerations cannot be given too much weight in a district such as the Loop District of Chicago where the density of pedestrian traffic is great. Here, the consideration of the safety and convenience of the users of the sidewalks must be the determining factor, and it is extremely doubtful if any rule can be put down. Even in these districts, however, the radius of curb returns should be such as to permit free turning movements and the radius should be made to approach that mentioned in the previous paragraph, that is 25 ft., or as nearly as may be permitted by the sidewalk conditions.

2—Maximum Crown of Pavements

Most authorities agree that if drainage were not necessary the ideal pavement section from a traffic standpoint would be a level surface. Since drainage is necessary, it must be considered. The former crown formulas such as Warren's, Rosewater's, etc., and the earlier ones which gave rather high crowns are being discarded for empirical figures and flatter crowns. The reason for this is that with the more true surfaces now common on the modern pavement, the former steep crowns are not necessary to insure lateral drainage. There are certain factors, however, that tend to prevent crowns on pavements in a city like Chicago from being reduced to the degree that has been reached by some highway engineering organizations. One of these factors is the flat topography of Chicago. Another is the accumulation of snow, slush and ice in winter.

This topographical condition has resulted in the practice of securing longitudinal drainage by varying the depth of the gutters below the top of curb from the summits to the inlets. This results in a longitudinal undulation which is modified by varying the crown. When so modified the longitudinal undulation is not perceptible to any one driving within reasonable speed limits. The minimum crown, used at summits, varies from ¾ per cent to 1 per cent of the roadway width in feet. The maximum crown, used at inlets, is approximately 2 per cent of the roadway width in feet.

The winter conditions with snow and slush require a slightly steeper transverse slope, to keep the surface reasonably well drained, than is necessary in warm climates. For such conditions where systematic snow removal is not in effect, the above mentioned minimum slope is inadequate, but it gives a measure of drainage and in such cases a standard adopted must necessarily be somewhat of a compromise between conflicting demands. On the other hand, the above maximum crown is not ideal from the standpoint of avoiding skidding when wet or slippery. However, the fact that the surface of the pavement follows a curved arc instead of intersecting planes results in the two central quarters which carry the faster traffic having a much flatter crown than the two outer quarters which carry the slow traffic and parked vehicles.

3—Protecting Sewer Openings, Drains, Etc.

There seems to be little that can be established as general practice in this regard, but there are certain factors which seem to require emphasis. Inasmuch as it is necessary to depress the cover or grating over a catch basin inlet in order to permit the ready flow of water from the pavement, special precaution should be taken to insure construction sufficiently strong to prevent any further depression due to the impact of heavy vehicles passing over the inlet. Sewer openings should be of ample capacity to carry away ordinary accumulation of trash and permit the speedy removal of water and slush.

The minimum height of curbs may be zero at crosswalks and in such cases the movement of pedestrian traffic is facilitated. However, it may be objected that a careless driver may drive upon the walks. This is true but a reckless driver is as likely to drive over a 7-in. curb as a zero curb. The maximum height at cross walks should never exceed 7 ins.

4—Height of Curb

The minimum heights of the curb at intermediate summits between intersections should be 2 ins. Less than this fails to give a clear line to the edge of the pavement and fails to retain the slush and water likely to be present at times.

The maximum height at inlets depends upon the distance between basins or inlets, the slope of the street and the height of the curb at the summit. An ideal maximum is 7 ins. but details of design and consideration of economy in sewer appurtenances frequently indicate a curb height of eight or nine inches which should be permitted in particular cases.

5—Safety Zones for Street Car Loading

Indiscriminate use of safety zones for street car loading should be avoided, but where it is found that the amount of traffic warrants the use of a safety zone, the elevated type is preferred. Safety zones are now being constructed in Chicago of concrete elevated 5 ins. above the pavement and having the ends sloped. This type of safety zone has many advantages but wherever one is installed a mushroom light should be placed at least at its head to provide sufficient warning at night. Mushroom lights should be installed at each end of the safety zones which are not elevated and it may be desirable in congested sections to provide warning signs on removable standards. The elevated safety zone permanently settles the question of marking and provides easier entrance to street cars. There are now 140 safety zones in Chicago, most of which are of the temporary type; that is, restrictions are removed at periods of light traffic. This is regarded as a temporary expedient and is under police regulation. The permanent elevated safety zone is thought to be more satisfactory. The greatest need for safety zones arises at the time of maximum passenger movement which conincides with the time of maximum vehicular movement but during times of light traffic, which invariably moves rapidly, there is continued need for safety zones. Removal of safety zone signs at such times is dangerous because of the false sense of security on the part of waiting passengers who think they are protected because they are standing on a portion of the pavement which is designated by paint as a safety zone.

6—Safety Islands on Boulevards

Safety islands at important intersections on boulevards are recommended and should be elevated and lighted. These zones should be as narrow as feasible so as not to reduce appreciably the traffic capacity of the boulevard.

7—Width of Traffic Lane

An extended examination of the literature published on this subject discloses practically nothing on the width of traffic lanes for city streets. There seems to be an almost universal agreementt on a width of 10 ft. for traffic lanes on country highways. It is thought that this should also be adopted for boulevards and streets devoted to fast-moving traffic. On heavy-traffic streets, it is thought that this could be reduced to 9 ft. for the reason that such traffic moves slowly. Further reduction is not thought advisable because of the present of wide motor truck and busses. Nine feet seems to be generally regarded as sufficient for parallel parking.

8—Marking Traffic Lanes in Streets

In general it seems impracticable to mark more than the center line of streets. It might be desirable to mark additional lanes at such places as winding drives through parks and on boulevards, but in general the traffic over such streets seems to take care of itself quite satisfactorily.

9—Markings for Safety Loading Zones

This is covered under section 5.

10—Concave or Center Gutter Streets

Concave street pavement has been constructed in the new market district between Morgan Street and Racine Avenue.

Several other streets are now under contract to be improved with this type of pavement.

The pavements in the Market district have given satisfactory service so far. This district, however, has a very specialized type of traffic. Numerous arguments have been made for and against this pavement section. It appears quite certain that a saving in sewer costs can be effected and a saving in filling, but if cutting is required the latter item will be increased.

From the standpoint of expediting traffic and of ease and safety, this type of street has yet to demonstrate its desirability.

11—Sidewalk Obstructions

Certain sidewalk obstructions may be removed while others are more or less stationary. Trolley poles and fire plugs are located according to more or less inflexible conditions. Trash boxes should never be permitted to be located near the corner. Mail boxes would be just as satisfactory if they were installed on the building fronts as soon as the people became accustomed to looking for them there. News stands are the worst offenders. They invariably seek the corners. They should not be permitted within 25 ft. of an intersection and should be located, preferably, in the middle of the block. City ordinances permit such stands to sell newspapers only. Practically all are violating this ordinance. The size of the news stand should be limited to that which is sufficient for the display of newspapers only.

12—Gutter Openings for Sidewalk Crossings

The practice of building an extension of the sidewalks into the street and providing an under passage for the gutter at the curb line, has been discontinued in Chicago but many old streets with such cross walks exist. This has the effect of making travel in the outside of the street almost impossible.

13—Battered Curbs

Battered curbs have been used on many pavements and have certain advantages. Two of the principal advantages claimed for such curbs are: (1) The ease of turning an automobile out, even when parked tight up against the curb, and (2) There is not the tendency for wheels to rub against this curb thus saving damage to sides of tires and rims and also to the curb itself.

On pavements where the topography lends itself to a curb design of uniform height this type of curb offers little difficulty. But with varying curb heights it presents several difficulties. If a uniform rate of batter is maintained and the line of connection with the gutter is held straight, the upper roadway face will meander in and out at the summits and inlets respectively. If the upper face is held to a true line, the lower edge meanders giving at some places a wider roadway and at others a narrower width. All these cause difficulties in setting concrete forms. If both top and bottom are held to a straight line and the rate of batter is varied a warped surface results with added difficulty in setting forms. In addition to these items, the appearance of poor alignment and the added opportunity its variableness would offer the many lawyers, who levy tribute on Chicago's improvements, to make still more vicious attacks are further reasons against its adoption in Chicago.

It is understood that the city of Chicago has abandoned the combined curb and gutter due to many failures of the gutter section. It proposes to use a straight curb 9 ins. wide by 20 ins. deep which will be installed after the pavement is built. The gutter will be built integral with the pavement and the curb will have a vertical face.

NEW WATER FILTERS AT BUFFALO, N. Y.

By Wellington Donaldson, of Fuller & McClintock, Consulting Engineers, New York, N. Y.

(From the "Nation's Health" for September.)

When the lake gate was closed on July 23, and the entire water supply of the city was for the first time passed through the newly completed filtration plant, Buffalo entered into a new phase of its water supply development and placed itself in the list of important cities with modern water purification works.

Originally the taking of water through intakes more or less remote from shore was considered to fulfill all the requirements of a satisfactory water supply for the various cities located on the shores of the Great Lakes. With the steady growth of population, imperfections appeared in these arrangements, once regarded as eminently satisfactory, and to minimize the effect of local sewage pollution, as well as to secure water of greater physical attractiveness, newer intakes have been extended farther from shore into deeper water. The manner in which some of the larger Great Lakes cities

have tapped the deeper and less polluted water by placing intake structures or "cribs" at a distance of miles from shore and bringing the water through tunnels in the rock to the land pumping stations is in itself a unique and brilliant chapter of engineering achievement.

Chlorination, which began to be adopted generally in 1911-1912, first through the use of hypochlorite and later liquid chlorin, has been of inestimable benefit in protecting the lake shore populations from the ravages of water-borne disease. It has given protection when in many cases none existed. It has provided a "breathing spell," so to speak, for water supply to catch up with water pollution. However, experience with chlorination has made known its limitations as well as its benefits, and one by one the lake cities have been brought to realize the advantages of filtration, not only as a dependable first-line defense against typhoid and allied diseases of bacterial origin, but as a means of securing water, clean and attractive at all times.

In the matter of improving the water supply by filtration the smaller lake communities have apparently displayed more initiative than have the larger cities. While Ashland, Loraine, and other smaller communities provided filtration plants at an early date, it is not until recently that the larger cities, with the exception of Toronto, met their responsibilities in similar fashion. It took an epidemic of typhoid to make Erie provide a filtration plant in 1914. Filtered water was partially furnished in Cleveland in 1915, but not for the entire city until 1925. The Detroit filters went into operation in 1923. With filtered water now furnished in Buffalo, this leaves Milwaukee and Chicago as the outstanding examples of major lake cities with unfiltered water supplies.

In regard to bacterial quality of its raw water supply, Buffalo is more fortunate than most large lake cities by reason of its geographical position. With its new intake located at the point where Lake Erie converges into the Niagara River, the supply is of very low bacterial density and is safe from pollution by the city's own sewers, whatever might be said of the ethics of turning this sewage into Niagara River to the detriment of other supplies below. However, the constant passing of shipping and pleasure craft in the vicinity of the intake holds a threat not to be entirely disregarded. The presence of microscopic and other forms of life has made the water a subject of complaint at times and the turbidity stirred up by occasional lake storms helped to make the decision for filtration.

Buffalo had the beginnings of its public water supply in 1832 when spring water was piped in bored logs to a portion of the community, according to George C. Andrews, who in a recent paper before the American Water Works Association, gave interesting notes on the development of the supply to date. In 1852, a private company installed a water works system taking water from the Niagara River, pumping to a reservoir, and distributing through cast-iron mains. Ownership of the water works passed to the city in 1868. In 1875 a new intake was constructed in Niagara River and connected by a tunnel to the shore pumping station. In 1894 was built the 116 million gallon distribution reservoir. In 1902, a typhoid epidemic emphasized the need of additional protective measures for the water supply and caused the construction of the present intake at the head of Niagara River, together with connecting tunnels and the new Ward pumping station, the intake being completed in 1913 and the pumping station in 1915.

As a safeguard, a chlorination plant was installed in 1914 at the intake crib and used at that location for about ten years, when chlorination was changed to the Ward pumping station on shore. In 1921, the council voted for the construction of a filtration plant, and this plant is just now completed and in operation. It may be interesting to note that in 1903 the invested capital of the water works was about $7,400,000; in 1916, about $17,200,000; and at the present time, with the completion of the new filtre plant, costing about $3,800,000, the capital investment is approximately -23,-500,000, according to Andrews.

Those portions of the supply works now functional and in daily use will now be briefly referred to in sequence of the water flow.

Raw water is taken from a circular crib or intake tower located at the head of Niagara River, where there is a normal depth of 28 ft. of water. The intake has 12 ports 6 ft. square located some 20 ft. below lake level.

From the intake crib, there is a tunnel, 6,651 ft. to the shore. This tunnel, 12 ft. x 11 ft. 6in., is in rock and at a depth of 65 ft. below lake level, and is concrete lined. The intake and tunnel have an estimated delivery of 450,000,000 gals. per

day. At the shore the main tunnel braches to supply the two pumping stations known as the Ward station and the Massachusetts Avenue station. To reach the latter a smaller tunnel, 9 ft. x 9 ft. 4 in. and 4,286 ft. long, was necessary. This is also driven in rock and concrete lined. With the building of the filtration plant the raw water supply to both of these stations has been blocked off and the raw water is now taken through a 12 ft. x 12 ft. conduit, 660 ft. long, to the low-lift pumping station which forms an essential part of the new filtration plant.

The equipment of the low-service pumping station comprises five motor-driven centrifugal pumps having nominal capacities of 15, 30, 45, 75, and 75 million gallons daily, against a head of 17 ft. Besides the main pumps there are also auxiliary pumps for dewatering certain portions of the plant and for pumping wash-water for the filters. Control of the main pumps is from the central switchboard. In addition to the customary switchboard instruments, each of the main pumps has a separate indicating watt-meter. Valves on the suction and discharge of the main pumps are operated by controls from the main switchboard.

The covered coagulating basin consists of two units about 200 ft. x 300 ft. and 24 ft. deep, having a nominal retention period of three hours at rated capacity of the plant. At the time of writing, only one of these units has been put into service.

The filters are of the conventional rapid sand type and bear a general similarity to other well-known installations. There are 40 units divided into two galleries or double rows with ten units each on a side. Each filter occupies a space of roughly 53 ft. x 33 ft. A central gutter divides the bed into two halves, making a net sand area of 1,400 sq. ft., which at the customary rating of 2 gals. per sq. ft. per minute is the equivalent of 4 m. g. d., or a total of 160 m. g. d. for the entire plant

The filters have perforated pipe under drains. The gravel depth is 16 ins., made up of five graded layers. There is a 26-in. depth of filter sand of approximately 0.38 to 0.45 mm. effective size.

The plant is designed to allow additions to the coagulating basin and the addition of 40 more filters, which will bring the final capacity to 320 m. g. d., making the plant the largest filtration in the world, in a single structure. It is now surpassed in capacity only by the Detroit works, which on the same basis of rating have a capacity of 240 m. g. d.

The clear water basin extending under the filters now built and under the proposed filter addition as well, has a capacity of approximately 18 million gallons.

A prominent feature of the Buffalo filter installation is the completeness with which the plant is furnished with meters, level gages, and other operating instruments. The raw water discharged by the low-service pumps is measured by twin 72 in. x 48 in. venturi tubes set in the raw water discharge conduit. The filtered water is measured by a single 12 ft. x 6 ft. venturi tube of square cross section set in the filtered water conduit leading to the Ward pumping station.

There is a venturi meter on each of the wash water lines to the two filter galleries. There is also a venturi on the line supplying wash water from the distribution system in case the wash water pump working automatically from the clear basin should be out of service for any reason whatsoever.

There are indicating or recording gages to show the water levels in the raw water conduit, the coagulating basin, the various compartments of the clear well.

For convenience in operation, the various meters and gages have been assembled in a special room of the headhouse known as the "control room." The general log of operation is kept in this room and from this point may be controlled the rate of flow of each filter unit in the plant.

Besides the instruments in the "control room" there are meters on the operating balcony of the low service pump room, showing the rate of pumpage and the principal water levels.

The master control feature of the filters differs in several respects from filter control devices used at some other well-known filtration plants. Each of the filter units is equipped with the usual controller, and may be operated individually, if desired, but all 20 units in one gallery may be controlled at will by a single sub-master control located on the gallery floor. In the "control room" there is a duplicate of these two gallery controls so that each of the 20 units in either gallery may be changed at will by the "control room" operator. Valved connections between the two gallery controls will allow the entire 40 filter units to be increased or decreased in rate simultaneously from the "control room."

The individual filter tables are of the conventional design and of the usual marble construction. Besides the controls and indicators for the five hydraulic valves, each table mounts a combination gage comprising rate-of-flow indicator, loss-of-head indicator, and loss-of-head recorder, the latter making a seven-day chart. A special feature of this instrument is the register of total gallons passed by the filter since it was last washed. The registers have a means of resetting to zero after each washing. The Detroit filters are the only other rapid sand plant where the individual filter units are equipped with a totalizing register, so far as the writer is aware.

A conspicuous feature of each filter gallery is the installation of paired illuminated dials, 30 ins., in diameter, at the half way point of the gallery. One of these dials indicates the rate of wash water in m. g. d. and the other indicates the depth of water in the wash water tanks on the top floor of the head-house.

The wash water for filters is normally pumped from the clear water basin by automatically operated motor driven pumps in the low service station which keeps filled two shallow cylindrical concrete tanks on the top floor of the head-house. These tanks hold approximately 140,000 gals. each. In case of accident to the wash water pump the tanks may be filled from the distribution system by an automatically operated hydraulic valve.

The only chemicals used in treating the water are aluminum sulphate and chlorin. For feeding the former, in powdered form, there are in the head-house three motor-driven dry feed machines of Gauntt type. For feeding chlorin there are duplicate chlorinators of the pedestal type located in a special room of the head-house. Indicating scales are used for taking the weights of chlorin fed.

The point of application of the aluminum sulphate is to the raw water flume on the suction side of the low service pumps. The chlorin is applied to the filtered water.

The filtered and chlorinated water is delivered to the main Ward pumping station through a short conduit and to the Massachusetts Avenue station through the above mentioned tunnel formerly used as a raw water supply.

Distribution of the water pumped from the Ward and Massachusetts Avenue stations is from the Best reservoir holding 116 million gallons, which furnishes the low pressure district and from the Kensington water tower which equalizes the pressure in a district of higher elevation.

AUTOMOBILE AND SUPERPOWER FORECAST NEW ECONOMIC ERA

By General Guy E. Tripp, Chairman Westinghouse Electric & Manufacturing Co.

Two new power developments—superpower and the automobile—promise to greatly add to our national wealth, increase the prosperity of the average family, and bring agriculture back into step with industry, General Guy E. Tripp, Chairman of the Westinghouse Electric and Manufacturing Company told the Congress of American industry in his address of "Power and Its Distribution" at Philadelphia recently.

"Civilized life without power is impossible," said General Tripp. "The more power a nation properly applies to production, the more prosperous are its people. But where there is no power, the people are poor."

General Tripp outlined the progress of power development in the United States from manual labor to waterpower, steam, and electricity, and indicated that at each stage the wealth of the people increased.

"Electricity has gained for the United States the industrial supremacy of the world," said the speaker. "Our workmen now have at their disposal an average of 3¾ horsepower per worker, which is about double that available to the workmen of England, the next most highly developed nation. Herein lies the secret of why, to quote the British Prime Minister, "the American workmen are able to enjoy better standards of living than any other working people in the world.'

'It has taken Europe many years to realize the immense gain in production that American industry has realized through the use of electric power, but she is now fully alive to the situation and we can look for rapid electrical developments over there.

"But in the meantime, American progress is showing no signs of halting.

"But is this progress to be along the same lines followed during the past century? And if so will the evils of our times continue to grow along with the good?

"Will our cities grow ever larger and larger? Our slums more crowded? Is the drain from our rural disticts to continue? Is the position of our farmers to

grow more and more unsatisfactory? Are they to be the hewers of wood and the drawers of water for those who find relief from manual labor by the use of power-driven machinery?

"If so, will our particular political institutions continue to flourish? Will not our industrial and commercial structure prove eventually too heavy for its agricultural foundations?

"Were conditions today what they were in, say 1910, it would be a farsighted man indeed who could honestly give optimistic answers to these questions. All things at that time seemed tending in the direction of centralization, concentration, and specialization—there were few signs that the tide might turn in some other direction.

"Today, however, matters appear to be in a much more hopeful state. There are two recent power developments, superpower and the automobile, which in my personal opinion point in an encouraging direction. Inasmuch as power applied to production and transportation has had a dominant influence on the nation in the past, I believe one is justified in expecting that these new power developments will usher in a new economic era in which many of the defects of the old will be rectified."

The Automobile

The automobile, General Tripp declared, is saving our workers an incalculable amount of time and is thereby adding to our national wealth. It is also, in marked contrast to the railroads, a decentralizing agency and is opening up an amazing number of square miles of heretofore waste lands to habitation and industry.

Superpower is making power available also everywhere, according to the speaker, and it is making it possible for industries to leave congested centers, thereby permitting them to reduce costs and improve living conditions for the workers.

"This will mean a check on the growth of our cities, a revival of town life, a re turn of that contact of industry with agriculture which was formerly so advantageous to the farmer, and will make living conditions in the country comparable with those in the city.

"The wealth of both the nation and its average family will be increased. Specialized sectional interests will tend to be obliterated because much of the country will be part agrictultural and part industrial. Hard times in any given industry will mean less suffering because few communities will find the majority of their workers out of employement at any one time. Political radicalism will be weakened.

"I must not be understood to be prophesying a millennium when troubles will be no more," General Tripp concluded. "Far from it. The new era will bring plenty of troubles of its own; but at least they will be somewhat different from those that have afflicted us, and they will be tempered by greater material welfare."

MERIT RATING PLAN ON CONTRACT BONDS

The Metropolitan Casualty Insurance Company of New York announce another underwriting innovation in the application of the merit plan to construction contract bonds. Contractors who can qualify under this plan will be able to obtain their bonds at rates substantially less than the standard rates which they are now paying.

During the past year or more there has been much criticism of surety companies for alleged laxity in contract bond underwriting, in that wholly unworthy contractors succeed in getting bonds from surety companies. The better class of contractors have complained that the issuance of bonds to unworthy contractors not only subjects them to unfair competition, but, since the premium rates are alike to all contractors, they are compelled to pay higher rates than their hazards justify.

Architects and engineers are also said to be dissatisfied with the present underwriting method of surety companies. They claim that this often results in the awarding of contracts to inefficient contractors who are often responsible for undue delays, trouble and expense. The resulting losses sustained by surety companies, it is contended, are responsible for premium rates which impose too heavy a burden upon the cost of construction, which, in the end is paid either directly or indirectly by the owners.

The proposed plan is carried out through an agreement between the individual contractor and the surety company, whereby compliance with this agreement qualifies the contractor for reduced premium rates shown below.

The Contractor Agrees:

To maintain a complete set of books, kept by a competent bookkeeper, and to have such books audited semiannually by

a public accountant who is satisfactory to the surety company.

To furnish the surety company semi-annually a financial statement which has been verified and certified by an approved public accountant, such statement to be on the surety company's form which is identical with that developed by the Joint Conference on Construction Practices.

To furnish an experience questionnaire on the surety company's form which is the same as that approved by the Joint Conference.

To furnish a copy of the architect's or engineer's estimate of monthly work performed on each contract covered by a bond of the surety company, and furnish semiannually a detailed report showing the status of all uncompleted contracts.

To furnish, on request of the surety company, in connection with any engineering project, a plan and equipment questionnaire on the surety company's form, which is the same as that approved by the Joint Conference.

To make application to the said surety company for all bonds which the contractor may be required to furnish during the next five years and to permit the surety company to write such bonds as are acceptable to it, provided, however, that—if in any particular case the contractor shall be requested by the owner or the owner's representative to furnish the bond of some other surety company, and the contractor deems it expedient to comply with such request, or if the contractor can obtain his bond from some other surety company at a lower rate, the contractor shall be relieved of any obligation to make application to the surety company for that bond. The surety company would, however, appreciate a written statement from the contractor outlining all conditions under which a lower rate is granted.

The Surety Company Agrees:

During the said five years not to charge the contractor rates higher than those above mentioned, and further agrees that if it should reduce its rates below those herein mentioned, it will make a corresponding reduction in the premium charged for bonds furnished to the contractor.

The premium rates to contractors who qualify under this plan will be as follows:

For all contracts for which the present rate is $15 per thousand, which is the rate for practically all classes of construction except street paving and dredging, the following will prevail:

Bond not over 10% of contract price, $5.00 per M on contract price

Bond not over 20% of contract price, $7.50 per M on contract price

Bond not over 30% of contract price, $8.50 per M on contract price

Bond not over 50% of contract price, $10.00 per M on contract price

Bond not over 75% of contract price, $11.00 per M on contract price

Bond not over 100% of contract price, $12.00 per M on contract price.

Contracts, including all those for which the regular rate is $7.50 per thousand on the contract price:

Deduct 50% from the premium in above table.

Street paving contracts, including all those for which the regular rate is $10.00 per thousand on the contract price:

Deduct 33 1-3% from the premium in above table.

This company is now in a position to handle bonds up to $500,000; and in the very near future its capital and surplus will be increased so as to enable it to handle bonds up to $750,000 or more, and that by the end of the year 1926 it will be in position to handle bonds up to $1,000,000. This limit applies to the amount of the bond, not the amount of the contract, so that if the bond is 50% of the contract price, a contract double the amounts above outlined could be bonded under this plan. There is no limit to the number of bonds which can be written for an individual concern on separate commitments or collectively for the industry as a whole.

JOB CONTROL IN CONCRETE

By Roderick B. Young, Senior Assistant Laboratory Engineer, Hydroelectric Power Commission, Toronto, Ont.

(From a paper before the American Concrete Institute.)

After studying earlier methods of proportioning, the field application of control of concrete was made on a relatively small job known as the High Falls development. Other applications were made to the Nipigon development, where an opportunity was afforded to study the other factors entering into quality control of concrete; that is, the control and handling of materials, mixing plant operation, placing and curing, the conclusion being reached that the design of the propotions was only one step and possibly a minor step in the production of quality concrete; to the Chippewa-Queenston development where an important outcome of

preliminay work was the decision to change the manner of stating water-cement ratio, from a ratio of volumes to a ratio of weights.

At Nipigon, in 1920, it was found that the mixture could be entirely controlled by regulating the water content and that only occasionally did conditions arise requiring readjustment of the basic proportions. This was further confirmed by the experience in 1921 which showed further that when changes in the mixture did become necessary they could be made in the field without recalculating proportions, by restoring the mixtures to their original consistency, adding or omitting cement and water as required to maintain the water-cement ratio for the class of cement in hand.

A careful study of the question of the existence of a water-cement-ratio-strength relation led to the conclusion that such a relation was a practical basis whereby to proportion concrete mixtures. The study showed the variations to which it was liable and the limits under which it could be applied.

From the investigations of fineness modulus and surface area method of computing proportions, it was evident that in using these factors both cement and water were proportional, although only one was calculated.

Two important points are brought out by the investigation on the economies of concrete mixtures. The first is that for each combination of fine and coarse aggregate there is a ratio for which the cement content of the concrete is a minimum and the mixture contains more fine aggregate than is required for plasticity alone. Secondly, the sand content except for very fine sands can be increased several per cent above the minimum point without appreciable change in the cement content of the finished concrete.

Investigation of measurement of aggregates indicated that any volumetric method of measuring aggregate, no matter how carefully made, is liable to error, measurement by weight appearing to be the only method whereby these errors can be eliminated. Since the specific gravity of an aggregate is practically constant, its weight varies directly as the volume of its solids and the errors of measurement are those due to balancing the scales in the aggregate.

Before concluding the paper, the writer refers again to the design of mixtures and offers a warning based on his own experience in proportioning: Concrete mixtures should not be designed for strength alone unless strength is the only consideration.

Lessons from 7 Years' Experience

It does not seem advisable in a paper of this nature to attempt to list in a set of conclusions each of the many points brought out. It will suffice to refer very briefly to what the writer believe are the principal lessons to be learned from the seven years' experience of the Hydro-Electric Power Commission. These are:

1. The field control of concrete on the job is practicable and profitable.

2. The control of concrete on the job is applicable to work of all kinds and sizes.

3. The control of the quality of concrete is not a matter of designing mixtures nor of following some particular theory, but it involves every step in the production of concrete from the selection of the materials to the curing of the product.

4. While the water-cement-ratio-strength relation is subject to variations, with average well graded materials, no other means than this is necessary in designing concrete mixtures for a given compressive strength, but economy demands that cognizance be taken of the grading of the aggregates.

5. The concrete most economical in cement is not necessarily that having as much coarse aggregate as it is possible to use and still have its mixtures workable, but is usually one in which the sand is lightly in excess of this. The best combination of aggregate depends on the grading of both the fine and coarse aggregate.

6. Of the several processes in the manufacture of concrete, the measurement of aggregates and the placing of the mixtures are most important from the standpoint of quality.

7. Intelligent supervision of the materials and processes of concrete is essential to successful control of its quality.

8. The results of field tests of concrete should be interpreted with caution and in light of the conditions under which they are made, cured and tested, and for this reason comparison of field tests from different jobs is difficult.

STUDYING HIGHWAY FINANCE IN NEW JERSEY

Probably the most vital problem which the New Jersey legislature will have to

consider in the 1927 session will be that of making some provision for the further development of the state highway system. The idea was brought forth some weeks ago by Senator Arthur N. Pierson, well known as author of Pierson municipal bond laws of that state, who advocates a $60,000,000 bond issue as the most feasible method of financing his plan, which calls for highway extensions of approximately 1,000 miles and for country roads which would link up the main trunks of the present state highways. Senator Emerson Richards, of Atlantic County, one of the principal objectors to the Pierson plan, insists that the money should be raised from a gasoline tax and from increased taxes on buses and heavy commercial trucks which are a principal factor in the rapid deterioration of the roads.

It is thought, however, that the gasoline tax would be defeated, although it is regarded as being the more equitable of the two schemes, inasmuch as it places the financial burden of maintaining the roads on those who are directly interested and who derive the greatest benefit from the development of the highway system. Several definite reasons are given for this supposition. It is pointed out that the population of New Jersey, according to the latest estimate by the State Department of Health, is 3,697,023, while the total number of registered automobiles is 580,465. Of this number, 462,123 are passenger cars, which would mean that probably four or five persons are interested in each of the cars.

It would seem, therefore, that the greater proportion of the people of the state would have sound reasons for opposing the gasoline tax and, in addition to this, must be considered the widespread interests behind the passenger buses and commercial vehicles, which would apparently cause tremendous opposition.

Under the Pierson project the interest charges on the $60,000,000 bond issue would total about $20,000,000 during the fifteen years' life of the bonds. Opponents of the plan object to this scheme as it amounts to one-third of the money to be borrowed on long-term bonds for short-term improvements. On the other hand, advocates of the bond issue argue that the roads are needed now and that the money realized from a gasoline tax would be spread over a period of years, which would not allow for rapid enough immediate highway expansion to meet the ever-increasing traffic on New Jersey roads.

It is claimed by the proponents of the gasoline tax that, inasmuch as New Jersey is one of the few states that has not levied such a tax and as the automobile registration fees are low, the tax would be justified. It would be opposed by the car owners, however, on the grounds that it would be, in effect, double taxation, and that the present license fee covers the cost of the roads.

It is certain, however, that in view of the urgent need of an increased highway system in New Jersey to handle both the local traffic and the great volume of interstate travel, the question of a road bond issue or a gasoline tax will be one of the dominant issues of the 1927 legislature.

ANNUAL SOUTHWEST ROAD SHOW AND SCHOOL

The second annual Southwest Road Show and School will be held in Wichita, Kansas, February 22, 23, 24, 25, 1927, under the auspices of the Wichita Thresher and Tractor Club, Inc. This Show and School covers more than nine states and will be staged in Wichita's two million dollar Exposition Building, which covers almost a block, has more than three acres of space available for exhibiting purpose, and was the scene of the very highly successful initial Road Show and School.

The Good Road School will be under the direct supervision of the Kansas State Highway Commission, K. S. A. C., with the cooperation of the Southwest States, Federal and State Highway Engineers, and other organizations in the Southwest that are interested in the School and Good Roads.

The United States Bureau of Public Roads, represented by Thos H. MacDonald, Chief of Bureau, wrote the club at the termination of the very successful initial Road School and Show: "You can count upon us for a continuance of the cooperation extended this year." His department furnished the largest exhibit of its kind that had been placed anywhere at any one time to that date.

More than 30,000 sq. ft. of floor space has been alloted to the Southwest States for Good Road School Exhibits, the United States Bureau of Public Roads and other exhibits that will be brought to Wichita for the benefit of the Good Road School.

NEW YORK MUNICIPALITIES AND MOTOR REVENUES

(From the Bulletin of New York State Bureau of Municipal Information issued Oct. 1, 1926, by the New York State Conference of Mayors and Other Municipal Officials.)

At the hearing in Rochester on September 21 by the joint legislative commitee on motor vehicle legislation the executive secretary of the conference presented the following statement:

"The position of the conference, as determined by the cities and first class villages, in respect to the problem before you is this: it is not specifically urging the imposition of a gasoline tax, although many of the municipalities favor such a tax. It is most concerned with the division of revenue now received from the motor vehicle registration fees or that would be received from a gasoline tax if imposed. All of the municipalities urge that the state give directly to them a share of this revenue to be used for highway purposes, traffic regulation and snow removal. They put forth the claim that they are both entitled to and need this revenue.

"Their claim that they are entitled to this revenue has been substantiated by the special joint legislative committee on taxation and retrenchment which made a very exhaustive study of this subject in 1924. The municipalities call your particular attention to this committee's report to the state legislature in 1925 (Legislative Document No. 97). We desire to have you place in your records the committee's findings. This gives a detailed statement, based on official reports, of what the motor vehicle is now costing the cities and villages.

"As to the needs of the municipalities sharing this revenue we desire to place these facts before you: nearly one-half of the city tax dollar is now used for highway and education purposes. These two activities are responsible for most of the increase in the cost of city government. Up until this year the law authorized villages to spend one-half of their tax dollar for highway purposes. A number of villages last year reported to the legislature through the joint committee on revision of the village law that this limitation was handicapping them. The legislature, therefore, removed it, permitting any village to spend as much of its tax dollar as it desired for highway purposes.

"Most of the cities and all of the villages have either a constitutional or statutory limitation on the amount of money they can raise by taxation in any one year for municipal purposes. The maximum limitation is two percent of the assessed valuation. The minimum limitation is one percent except in those municipalities where a specific sum is named.

"All of the municipalities will this year suffer a loss of revenue from indirect sources thus having their taxing powers reduced. Changes in the law by the last legislature will reduce the revenue received by all the municipalities from the state income tax and that received by most of the municipalities from the bank stock tax. The approximate loss will be $5,000,000. It will, therefore be seen that unless some new revenues are provided by the state, the municipalities will have considerably less to spend in the future for highway construction and repair, proper traffic regulation and snow removal.

"The state's program for grade crossing elimination will also seriously affect the paving programs of many municipalities. If this program is put through as now contemplated, the borrowing capacities of most of the municipalities either will be wiped out or seriously impaired. It will, therefore, be impossible for many to issue bonds for highway construction. A fair share of the revenue from either the motor vehicle registration fees or a gasoline tax will permit all of the municipalities to give that paving, traffic regulation and snow removal service which motorists expect and are now demanding.

"In order that your committee might have first hand and official information on this subject, the conference two weeks ago requested the mayor of each city and the president of each first class village to send a statement for presentation at this meeting. We have to date received replies from sixty-four municipalities. Copies of these will be filed with you. They may be summarized as follows:

"All except four of the municipalities advocate that a share of the revenue from the gasoline tax if imposed be given directly to the municipalities. One does not answer the questions specifically as it is opposed to a gasoline tax. Two others advocate that a share of the revenue from the motor vehicle registration fees be given directly to the municipalities. One advocates that the revenue be

used for construction and repair on main trunk highways.

"Twenty-five municipalities express themselves as in favor of a gasoline tax provided a share of the revenue is given directly to the cities and villages.

"Seven express themselves as opposed to a gasoline tax, but all except two of these advocate that a share of the revenue of this tax, if imposed, be given directly to the cities and villages.

"If no gasoline tax is imposed by the state, all except one of the municipalities urge that a share of the revenue from the motor vehicle registration fees be given directly to the cities and villages for highway construction and repair, traffic regulation and snow removal."

The executive secretary also informed the committee that the cities and villages, working through a special committee, are endeavoring to solve the problem of uniform regulations by automatic traffic signals and that before the committee is ready to report to the legislature, specific recommendations will be presented.

All of the groups represented at the hearing seem to feel that a gasoline tax will be imposed at the coming session of the legislature. All of the farm groups, acting through their conference board, have agreed on a bill, a copy of which was presented to the committee. This bill provides that there shall be a tax of two cents on gasoline with a reduction of twenty-five percent on motor vehicle registration fees and that the revenue from the gasoline tax, estimated at $18,000,000, shall be distributed as follows: 30% to the state for state highway purposes; of the remaining 70%, 15% to New York City, 35% to all other cities and all villages to be distributed on a mileage basis; the remaining 50% to go to the counties for use outside of cities and incorporated villages. The organized motorists demanded a 50% reduction in registration fees and a guarantee that any revenues received by cities and villages shall be used only for highway purposes.

ARGUMENT AGAINST ROADSIDE ADVERTISING

Mr. F. M. Sergeant of Rhinelander, Division Engineer of the Wisconsin State Highway Commission, recently issued a public letter appealing to roadside advertisers to refrain from posting illegal advertisements on the highways. Mr. Sergeant advances an argument that cannot be denied, and we believe it will get results in Division No. 7. Perhaps other divisions or counties might use a similar appeal to good advantage. The letter follows:

"In driving through the country the past few days, we notice that there has been a new outbreak of cheap advertising on the highways. Section 86.19 of the statutes provides that there shall be no advertising matter placed on our highways, and the county highway commitees are charged with the enforcement of the law, and have gone to considerable expense and trouble in removing such matter during the past few months.

"Political advertising, county fair posters, and so forth, come under this head.

"It is a safe assumption that 90 percent of the people putting up out-door advertising matter are auto owners, and it is money paid in by auto owners that must be spent to tear down this matter when it is placed on the highways. The time of the patrolman that was spent in removing one of these posters might better have been spent in removing a stone that some of you bruised a tire on a few days ago, or in filling up the chuck hole where some other autoist is apt to break a spring, or the same number of minutes work with a shovel would have let the water out of that hole where you splashed your clean car all up last Sunday.

"Remember, that keeping the highways clear of advertising matter is in the line of a maintenance requirement and no patrolman or no county can be rated as high as we would like to have them, unless this is done. Get into the game, be a good sport, and help the patrolmen to keep a good looking section as well as a smooth riding one."

THE NEW HIGHWAYMAN

By Glenn Frank, President University of Wisconsin, Madison, Wis.

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One of the unhappy tendencies of our time is the tendency to think that only the more showy and professionalized callings are socially important.

The poets and painters, the priests and prophets, the soliders and statesmen, have come to be looked upon as the guardians of the soul of civilization and the godfathers of its romance.

The more prosaic callings have come to be looked upon as bread-and-butter enterprises from which men must escape, at least for part of their time, if they are to feel the thrill of romantic enterprises or have the sense of serving creatively the spiritual needs of their civilization.

The other day I stood on a platform and looked into the faces of a thousand or more highway engineers. They were the men who have conceived and created the magnificent highway system of an important section of the United States.

It was a very modern and standardized looking group of men; their manners and their movements were very matter-of-fact. They were discussing the mixture of cement and the establishment of grades and curves. They seemed animated by no sense of the romantic in their enterprise. Clearly they were men who would have welcomed a fling in some far country of adventure as soldier or prospector or pioneer.

But as I looked at them and thought of the social and spiritual influence they had exerted upon American life by the simple process of building good roads, they seemed to me as romantic as medieval knights in plume and armor.

The greatest social services are rendered unconsciously as by-products of men's ordinary enterprises. It had been so with these highway engineers.

They had set out to build good roads and they had built a new kind of civilization. Here, for instance, are some of the things we may chalk up to the credit of the men who have developed American highways and highway transportation:

They have saved rural communities from the isolation that starves men's souls and shrivels their spirits.

They have reduced the narrow provincialism of American towns and cities by linking them up with other towns and cities.

They have made possible the development of rural mail service.

They have rendered the parcel post service possible.

They have made possible a reduction in the cost of getting farm products to and finished goods from railroad shipping points.

They have made the educational and cultural influences of America available to wider and wider areas.

They have, as a by-product of the prosaic business of building roads, transformed the living conditions, the thought, the culture, and the life of the American people.

The man who sees the spiritual by-products of his business or profession doubles the joy of living.

CEMENT TESTING IN WISCONSIN

By T. J. Vitcenda, Materials Engineer, Wisconsin State Highway Commission, Madison, Wis.

(From "Badger Highways" for September, 1926.)

Anyone who has been directly connected with concrete construction work in Wisconsin has no doubt come across tags attached to several bags of cement in a carload which state that the cement has been tested by the State Highway Commission. It will probably be of interest to explain what the inspection tags mean and what work is necessary to make those tags of value.

To thoroughly comprehend the meaning of the tags, it will be well to begin at the cement mill and trace the sample through all the steps until it has been tested. The Wisconsin Highway Commission has inspectors at eleven cement mills in seven states. These mills furnish the state with all the cement used in highway construction. The cement company informs our sampler daily of the cars they are shipping for highway purposes. The sampler obtains his samples, weighing about a pound each, from five or six bags from the carload. One sample is taken when the car is beginning to be loaded; other samples when the car is partially loaded, and the last one is taken near the door. In this manner samples are taken from each end and from the middle of the car.

The samples are taken out of the bag of cement through the filling valve, a lapped opening at the bottom of the bag, through which all bags are filled. The sample of cement is placed in a small paper bag, together with the stub of the tag which you see fastened to the bag of cement. The tags are attached at the time the sample is taken. When the car has been loaded, the samples are placed in pasteboard containers made expressly for the purpose, and prepared for mailing. The sample is mailed the same day and arrives at Madison the next or second day. One man from the laboratory goes to the post office each morning and collects the samples. They arrive at the laboratory about seven o'clock and the testing begins immediately.

Only physical tests are made on the cement at the laboratory. The chemical tests are of little value outside of the cement mill, where they are used to control the mix. The first step in the work of testing is the registration of samples. Next, the individual pound samples are combined and the proportions for the soundness and time of set pats are weighed out. One man makes all of the pats for these tests, as it is essential that the variation due to the personal factor be reduced to a minimum. The soundness and time of set tests are followed by the tests for mortar strengths. This operation is the longest and requires the most skill. It is very essential that the correct amount of water be used in mixing, and that the proper pressure be applied when tamping the mortar into the molds.

When the soundness and time of set pats are made they are placed in a closed tank, which has a very humid atmosphere. The mortar specimens are placed in the same tank and are kept there for 24 hours. After two to six hours the pats are examined individually for time of set, and are again placed in the tank for the remainder of the 24 hours. This constitutes the necessary work for the first day.

The following morning the briquettes, as the specimens of the cement-sand mortar are called, are removed from the forms and placed under water to cure. The soundness pats are removed from the moist tank and placed in a steamer, where they are subjected to steam for five hours. After this steaming period the pats are removed and examined for soundness.

On the third day after making the mortar briquettes half of the specimens for each cement are taken out of the water and tested in tension. This test furnishes the results of the three-day test. On the seventh day the remainder of the briquettes are taken out and tested in the same manner.

A fineness test is also made on all cement. This test is made on the first day. It is made by screening a sample of cement through a sieve having 200 meshes per linear inch. It is required that a minimum of 78 percent of the cement pass the sieve.

These tests constitute all that are made in a routine analysis of the cement. A portion of the remainder of the sample is put into a glass jar, sealed, and stored for a period of about two weeks. This sample is saved so a check test can be made in case there is any question about the results of the first one.

The results of all tests are recorded on form sheets for the purpose and sent to the interested parties. When a cement fails the soundness test the consumer of the cement is notified by wire not to unload the car until further notice. A new soundness test is made immediately, and if the cement again fails the car is held until the mortar strength results are out. Very seldom will a cement pass the mortar tests when it fails the test for soundness. When such a failure occurs, the consumer is notified that the cement has failed to meet the requirements of the specifications and is rejected for use in any highway construction.

When one considers that often the cement sample has arrived in the laboratory before the car from which the sample was taken leaves the railroad yards, it is reasonable to believe that the cement has been fully tested before the car arrives at its destination. One can also realize, then, the necessity for speed in performance of the tests. It would be useless to test the cement if it were used before we knew the results of the tests. Furthermore, to prevent any delays in the testing, it is necessary that the operators work seven days a week. It is estimated that approximately 3,900 cars of cement will be tested at the laboratory of the State Highway Commission during 1926. All of the cement in these cars will be used in the improvement of our highways and bridges.

OFFICIALS TO DISCUSS ROAD AND STREET IMPROVEMENTS

Paving of secondary roads to relieve over-burdened trunk line highways in congested districts will be one of the suojects to receive chief consideration at a joint meeting of the American Society for Municipal Improvements, The Asphalt Association, the Association of Asphalt Technologists and other organizations to be held in Washington November 8 to 12, next. The meeting will bring together between two and three thousand road and street experts for the discussion of many problems confronting the municipalities of the country.

"A glance at the highway activities," says J. E. Pennybacker, general manager of The Asphalt Association, who, with C. W. S. Sammelman of St. Louis, secretary of the A. S. M. I., has charge of the detailed arrangements, "indicates a strong leaning toward concentration of expenditures on trunk lines. This leaves the secondary roads to shift for themselves and causes traffic to seek the trunk lines to the congestion of the latter. This congestion is actually driving pleasure traffic off the highways. Motorists who otherwise would be enjoying drives on back country roads are kept at home because of the congestion at important points on the trunk lines.

"The great trunk line highways which parallel railroads have their place and serve a vast stream of tourist traffic, interurban trucking and pleasure riding for cities and towns but, in general, the roads which serve best the rural needs are those which lead to the railroad stations. These farm-to-market roads make up that great class known as secondary and this class of highways should be receiving increased attention on the part of all concerned."

The matter of planning and constructing paved streets to accommodate safely future traffic will also be a leading topic at the sessions. Other subjects to be considered during the week include street inspection, lighting, cleaning and snow removal, traffic regulation, sewers and sanitation, water supply, garbage disposal, public recreation and city planning, finance and legislation.

Secretary of Commerce Herbert Hoover, has been invited to make the opening address. Other principal speakers will be U. S. Senator George H. Moses of New Hampshire, chairman of the Senate Committee on Post Roads; Arthur W. Blanchard, professor of highway engineering, Michigan University, and president, American Highway Traffic Association; R. H. Simpson, chief engineer, Columbus, Ohio; E. E. Butterfield, Municipal Chemist, New York City; Gene Abson and H. W. Skidmore of the Chicago Paving Laboratory; R. K. Compton, director of public works, Richmond, Va.; C. H. Henderson, chief engineer, Rhode Island State Board of Public Roads; Francis P. Smith, New York City; J. D. Black, Chattanooga, Tenn.; J. B. Pridgen, North Carolina State Highway Department; S. E. Fitch, Jamestown, N. Y.; R. M. Smith, Ontario Provincial Highway Department; A. T. Goldbeck, National Crushed Stone Association; C. M. Pinckney, chief engineer, Borough of Manhattan, New York; F. B. Bosch, Harrisburg, Pa.; W. J. Emmons, U. S. Bureau of Public Roads, Washington, D. C.; W. E. Rosengarten and Prevost Hubbard, New York City; W. W. Horner, chief engineer, St. Louis; B. S. Russell, Cleveland, O.; A. F. MacAllum, Ottawa, Can.; A. K. Vickery, city engineer, Denver Colo.; H. F. Harris, Trenton, N. J.; N. S. Anderson, South Carolina Highway Department; Jay Downer, chief engineer, Westchester County Park Commission, New York; J. M. Page, chief engineer, Oklahoma Highway Department; I. W. Patterson, Meriden, Conn. and F. E. Everett, commissioner and state engineer of New Hampshire. Among those who will preside at the sessions are: C. G. Sheffield, New York, president, The Asphalt Association; J. H Cranford, Washington, D. C., ex-president, American Road Builders' Association; R. Keith Compton, director of public works, Richmond, Va., and Francis P. Smith of New York.

Speakers listed for the sessions of the American Society for Municipal Improvements include: Julius Adler, Philadelphia, Pa.; H. E. Breed, New York City; A. R. Hirst, Des Moines, Iowa; Thomas H. MacDonald, chief U. S. Bureau of Public Roads, Washington, D. C.; A. W. Dow, New York; Henry Welles Durham, Managua, Nicaragua; W. E. Worcester, Philadelphia, Pa.; W. A. Brownfield, Louisville, Ky.; Prof. Harry Tucker, North Carolina State College, Raleigh, N. C.; T. J. Wasser, Jersey City, N. J.; F. A. Reimer, East Orange, N. J.; Major C. H Brown, chairman, City and Park Planning Commission, Washington, D. C.; E. A. Fischer, Rochester, N. Y.; P. L. Brockway, city engineer, Wichita, Kans.; F. O. Eichelberger, city manager, Dayton, O.; G. A. Parker, Hartford, Conn.; E. R. Kinsey, president, Board of Public Service, St. Louis, Mo.; C. C. Pashby, city clerk, Memphis, Tenn.; James R. Pollock, city engineer, Pontiac, Mich.; Henry W. Taylor, New York City; George B. Earl, New Orleans, La.; R. B. Morse, Hyattsville, Md.; J. Donohue, Sheboygan, Wis.; William Rudolfs, New Brunswick, N. J.; J. R. Boyles, Baltimore, Md.; J. B. Hawley, Fort Worth, Tex., and E. T. Leis, Playground and Recreation Association of America, Chicago, Ill.

USING PAVEMENT MARKINGS TO DIRECT TRAFFIC

How pavement markings can help to relieve traffic congestion is explained by Earl J. Reeder, an engineer on the staff of the National Safety Council, who has made a study of this subject in several cities where he has conducted surveys to ascertain the causes and remedies of automobile accidents. Mr. Reeder writes:

Of traffic rules and regulations this is a day of abundance and variety. From hamlet to metropolis, every community has its own traffic code. Not even the local resident is able to bear in mind these rules and regulations as they apply to all streets, street intersections, and other locations within his community. Much less can the tourist hope immediately or even eventually to familiarize himself with all of the rules and regulations governing his driving as he goes from one community to another.

Some of this variety can be overcome through adoption of uniform laws and regulations. However, all cities are not the same as to street conditions and hazards. Nor are different sections of the same city alike. Consequently, for individual street locations it is necessary to have specific regulations. It is particularly difficult for even the local motorist to remember all of these localized rules without special reminders.

It is for this purpose that signs and pavement markings have come into common use. The former can be used in practically all places, but the latter can be used on paved streets only. It is on the paved streets, however, that the greatest volume of traffic moves, and consequently, that there is need for the greatest clarity regarding the regulations.

For some purposes the pavement markings supplement permanent signs except during those seasons of the year in certain climates where the pavement markings are obscured by snow or ice. A common example of this is the word "stop" and the straight line painted on the pavement at through street intersections, in addition to the "stop" sign at the curb. Under many conditions the "stop" sign is not readily observed, whereas the pavement marking is directly in the line of travel of the vehicle and, during the dark hours, is illuminated by the vehicle's headlights.

For some other purposes pavement markings represent the only satisfactory means of directing the driver where signs are not adapted to the purpose, but where some direction is necessary. A common example of this is the street center line at a curve to define lanes of travel for vehicles going in different directions.

Obstruction of pavement markings by snow and ice is not a serious objection because during such obstruction traffic is lighter and greater care is exercised in driving.

Pavement markings have been used for a variety of purposes. These uses may be generally classified as follows:

1. To mark the center lines of pavements on straightaways to divide traffic in the different directions, particularly at hill crests.

2. To mark the center lines of pavements on curves for the same purpose.

3. To mark the limits of crosswalks at street intersections and other points where they are established to show both the driver and the pedestrian where the latter is expected to cross the street in safety.

4. To instruct drivers to stop their vehicles at intersections with through streets, before entering them.

5. To outline the limits of safety zones, with buttons or stanchions as areas reserved for pedestrians, particularly street car passengers.

6. To define parking stalls, to indicate the manner of parking, and to indicate the limits of prohibited parking where stalls are not individually designated.

7. To indicate to pedestrians and drivers the necessary clearance for street car overhang, particularly at curves.

8. To define lanes of traffic in and adjacent to street intersections, particularly to show the lanes into which vehicles should be driven for movement in the various directions.

9. To indicate the approach to railway crossings.

Some of the above are suitable to general use while others are adapted only to special conditions. Much more general use can and should usually be made of practically all of these markings in most communities.

By common usage the following general specifications for pavement markings have been developed:

Center lines may be painted in either white or black, depending upon the na-

ture of the pavement, black on concrete and white on asphalt being the usual combination. These lines are usually painted with some type of hand-propelled machine. They should be 4 ins. in width. Inlaid markings may be used as described later. Sometimes these center lines are confined to hill crests and curves where it is not desired to apply them continuously along the pavement.

At right angle street intersections cross walks represent the continuation of the side walks across the streets, being represented by two parallel lines on the pavement surface separated by the width of the sidewalk. These lines should be 4 ins. in width. Some cities have found it desirable to use a yellow paint for cross walks to distinguish them from lines in other directions on the pavement to direct vehicles in movement along the street. At acute angle and irregular intersections the location of cross walks becomes somewhat more difficult. Where possible they should cross perpendicular to the curb lines so that pedestrians may takethe shortest path across the street, thus being subjected to a minimum amount of vehicle traffic. Inlaid markings may also be used for this purpose.

Where cross walks have not been designated by pavement markings on those streets intersecting a through street, the best practice is to extend the property line across the right hand side of the intersection, with the street center line extended back several feet from it and the word "stop" painted in large letters to be read by the approaching motorist. These letters are usually from 2 to 4 ft. in height and the tops of them should be placed at least 5 ft. in front of the line as it is approached by the driver. These pavement markings should not be considered to take the place of signs at the side of the street, but rather, should be used to supplement them. The lines may be painted with a pavement marking machine, but the lettering should be done with a brush and stencil. Inlaid markings are also used for this purpose.

Under favorable conditions, raised safety zones or street car loading platforms are considered preferable because of their greater protection to pedestrians. Where these are not practicable, painted or inlaid lines are used in conjunction with mushroom buttons, stanchions, or other similar substantial protection for the pedestrian. Where painted lines are used, it is sometimes considered desirable to use yellow or other color corresponding to the pedestrian cross walk lines.

For parking parallel to the curb the usual method of designating parking space is to paint or inlay a line parallel to and 7 to 8 ft. from the curb with lines connecting this to the curb at the limits of such parking stalls. Angle parking is usually indicated by parallel lines drawn out from the curb at the established parking angle and about 6 ft. apart.

Where it is not found practicable to paint lines parallel to the curb or at each stall for angle parking, the limits may be shown by lines perpendicular to the curb or at the established parking angle, at the limit of parking zones with a short line extending parallel to the curb at the outer end of the line from and in the direction in which parking is permitted. It is not desirable to outline areas of prohibited parking by lines parallel to the curb as such lines are usually taken to mean that parking is permitted.

The necessary clearance for street car overhang may be shown by lines parallel to and along tracks on straightways to warn vehicles against driving on the street car tracks or sufficiently close to them to interfere with the free movement of the cars. Or they may be used for curves only, being so drawn as to represent the line described by the rear corner of the street car as it turns the curve, which means that it will not be parallel to the car tracks. These lines are particularly important at curves.

There are several possible uses of pavement markings to indicate lines of vehicular movement at street intersections, including the circle for rotating traffic, the diamond for indicating the turns in various directions, and dividing traffic by lines into different lanes for turning both right and left and for straight ahead traffic. The lines should be about 4 ins. in width if they are painted and 9 or 10 ft. should be allowed for each lane of straightway traffic.

Railway crossings are usually indicated by transverse markings consisting of alternating diagonal bands of black and white forming a wide line across the street. This is a special type of marking and cannot be applied with the ordinary machine.

There is considerable variety in the kinds of paints used. Commercial brands of specially prepared pavement paints are commonly used, although a few cities prepare paints to their own formulae.

Some use the Bureau of Public Roads specifications.

White paint is most commonly used for the pavement markings, although yellow is quite common and red is used to some extent. Where more than one color is used it is customary to have one color represent directions for pedestrian traffic and another color for vehicular taffic.

The frequency of marking, when painted lines are used, depends largely upon local conditions and the amount of traffic at individual points. The most common practice appears to be a monthly repainting, although a number of cities practice painting every six months.

Various methods of inlaying lines and letters have been devised, consisting usually of concrete, colored bricks, rubber compositions or metal. The use of inlaid markings is increasing, although by far the greatest number of markings are applied with paint. Several manufacturers have developed inlaid markings adapted to particular purposes. Many of these serve the purpose quite well, giving a large measure of permanency. They are not adaptable to changes to conform to varying regulations as are the painted markings. Visibility and permanence are important factors in determining the kind of pavement markings to be adopted. When new, paint usually provides the greatest visibility, but frequent painting is required to maintain this condition, while the inlaid markings with a visibility that is usually somewhat lower than freshly painted lines, have the advantage of permanence.

Fabric markings to be pasted on the pavement surface have been developed and have been used to some extent.

In selecting the method of pavement marking to be used permanence, visibility and convenience of application must be considered. It is seldom possible to accomplish maximum results in all of these regards and in all uses to which they can be applied, from any one of the several methods described above. However, there is an advantage in a large measure of uniformity in any given community as less confusion results.

STREET LIGHTING PAYS FOR ITSELF

By L. A. S. Wood, Manager Street Lighting Section, Westinghouse Electric and Manufacturing Co.

The lighting of streets and highways is a public service which merits more attention on the part of municipal officials than is generally conceded to it. Street lighting is a service which was originally instituted by civic authorities to prevent crime; it was interesting only to criminals and to those who were compelled or desired to use the streets and highways after dark. Under modern conditions, it has become an important factor in municipal development.

The average city in the United States might well be classified as the best and worst lighted city in the world. In it will be found certain streets and districts which are well lighted. In it also will be found others that are outlined with lamps of such insignificance that they serve merely as street markers.

From this it is evident that in laying out street lighting systems, we are departing from the original purpose of street lighting—crime prevention—and are being governed largely by the effect of good street lighting as a means for increasing property values. This is a natural development brought about by modern conditions, but it should not cause us to neglect the original purpose of street lighting and favor the so-called better class districts over the poorer districts. The poorer districts and alleys which are notoriously badly lighted, require good street illumination, to as great, if not to a greater extent than the better class districts. I do not wish to infer by this that costly street lighting equipment of a highly ornamental character should be installed in the poorer class districts, but rather that the standard of illumination in districts producing smaller revenues from taxation should be as high as that in the better class districts.

Real estate operators recognize the advantages of good street lighting when preparing their properties for the market, and in many recent developments the street lighting system has been advertised as one of the attractive features of the sub-division. Hundreds of thousands of dollars have been spent in recent years by real estate operators in up-to-date street lighting, and it stands to reason that keen business men would not have spent this money if it did not return satisfactory profits.

Good examples of a far-sighted real estate development where an adequate street lighting system has been installed prior to the sale of building lots may be seen on Sheridan Drive, Tonawanda,

N. Y., which is destined in the near future to become one of the most important residential districts near Buffalo. In this development, although at present there is hardly a house to be seen, upwards of 1,700 Hollowspun granite standards, with Octagonal lanterns having refractors for directional light control, are already installed.

Green Street, Pasadena, illustrates what a progressive city is willing to do to develop a new district. Here, as on Sheridan Drive, there is hardly a house to be seen. The significant fact is that one of the first steps taken by the city was to install street lighting of the most modern type, in which an asymmetric distribution of light is obtained by the use of refractors for directional control.

Good street lighting pays for itself in enhanced taxable values, and the same conditions which make it an asset to real estate developments, make street lighting a financially desirable improvement for the city as a whole. Good street lighting improves the character of adjacent buildings, encourages better class stores and raises the district from poverty and squalor to prosperity. Every city has money enough for better street lighting. It pays for itself.

It is a much-to-be deplored fact that municipal authorities are apt to attach too much importance to the cost of adequate street lighting and to overlook the cost of inadequate street lighting, although the latter may become a heavy burden to the public because of accidents, crimes and other losses attributable to insufficient street lighting. If accidents or crime, due to inadequate street lighting, resulted in the punishment of those responsible for such lighting, municipal officials would undoubtedly show a greater interest in street lighting.

The average American city does not spend enough on street illumination. This is clearly demonstrated by the fact that only about three and one-half cents of each dollar collected by municipal taxation is expended on street lighting, while twenty-one cents of each tax dollar is spent on protection (police, fire department, etc.). Since adequate street lighting decreases crime and assists the police and fire departments, it would be logical to assume that an increase in the street lighting budget might be offset by a reduction in the budget for protection.

I sometimes think that in considering municipal expenditures, officials who have the control of public safety and welfare in their hands, are obsessed with the belief in a limitation which does not really exist. One of the best examples of the strength of a belief in an imaginary limitation is afforded by a polar bear in the Zoo in Forest Park, St. Louis. At any time in the day, this bear may be seen going through an unvarying set of motions in a large inclosure in which there is ample room for him to move about freely. Yet he confines his motions within a very small area. He walks in a beaten path—six steps forward and six steps back, forward and back, forward and back, hour after hour. His keeper when questioned replied that the animal was brought up in a cage just large enough to let him take those six steps forward and back. He became so accustomed to this performance that although he is now at liberty to move freely in all directions, the belief that he is still confined to his cage has become so fixed in his mind that he is unable to break it; he cannot comprehend the new situation. The keeper says the bear has the "small cage habit". He referred to it as something rather common. Have not some of us contracted the "small cage habit" in appraising our street lighting requirements?

Possibly some of the difficulties connected with securing adequate appropriations for municipal street lighting may be due to the fact that a number of municipal officials have the small cage habit when considering ways and means of raising funds for such purposes. There are many and various ways of financing street lighting systems, and, while local conditions are responsible for slight variations in procedure, in general the six plans outlined by Mr. C. M. Shepherd of Chicago are of such primary interest that I am taking the liberty of including them here:

"First: Payment of the installation costs, operating and maintenance charges by direct taxes.

"Second: Payment of the installation costs by means of bond issues, in which case the operating and maintenance costs, as well as interest and sinking fund for the bonds are taken care of by means of direct taxes.

"Third: Payment of installation costs by means of special assessment charges levied on a frontage basis, the operation and maintenance charges to be covered by appropriation from taxes.

"Fourth: Payment of the original con-

struction costs by local public service companies, the cash costs and fixed charges of the system to be paid by the municipality, in which case provision is usually made for the acquirement of the property by the municipality at a given time, on the basis of original cost plus accrued depreciation at such date.

"Fifth: Construction costs to be defrayed by some public body other than the municipality itself, in which case provision for payment is usually made on an installment basis, the deferred payments to bear interest, and the expense of operation and maintenance to be paid from municipal taxes.

"Sixth: Local street lighting systems are occasionally constructed and operated by neighborhood commercial or business men's associations on various plans, among which are the following:

"(a) Payment of costs of construction out of association funds, the operation and maintenance to be paid for by individual business men or property owners on a frontage basis; the construction work to be done by a contractor or by the local public service corporation, in which case a number of variations in the form of contract are possible.

"(b) Payment of costs of construction and operating charges by means of individual subscriptions.

"(c) Payment of costs of installation by means of local assessment on a frontage basis; the system when completed to become the property of the municipality and to be operated as part of the municipal system; the local association paying not only the cost of construction but also of the excess illumination, while the city pays the cost of the normal illumination.

"(d) Payment of installation charges, maintenance and operating costs by means of general special assessment exactly in the case of street and sidewalk improvements or of municipal utilities; the same conditions of ownership and contract applying as in item (c)."

In discussing the various methods of financing street lighting projects, it is necessary to recognize that there are two distinct classes of street lighting—the purely utilitarian and the ornamental. The former class consists of overhead lighting units supported on brackets or span wires and fed from overhead lines. The initial cost of such systems is comparatively low and they are generally financed under the first plan by contract with the local public utility company. The cost of ornamental installations operated from underground circuits, on the other hand, is high and it is recommended that these be financed under the third plan.

The difference in the first cost of the two systems is the crux of the problem and, when its relation to the annual street lighting budget is fully appreciated, many of the difficulties experienced in promoting modern street lighting projects will disappear.

Municipalities with street lighting services operated under the first plan will enter into contracts with the local public utility company at rates which will include, in addition to the operating and maintenance costs, fixed charges for interest and depreciation on the equipment. In the case of utilitarian street lighting where the fixed costs are low, the rate will bear a direct relation to the cost of current and maintenance. On the other hand, if the same plan is adopted for ornamental street lighting, the fixed charges for interest and depreciation will be high, owing to the greater initial cost of the system and they will form a large proportion of the total rate.

Municipalities pay the public utility company's street lighting bills out of annual maintenance budgets, and it is obvious that when the public utility rate is burdened with large fixed charges incident to ornamental street lighting systems, the municipalities will not have much money left to pay for adequate service, unless their annual budgets are materially increased. Under such circumstances, the municipalities will be paying fixed charges which should be debited to capital account out of their annual maintenance budget. Under the third plan, the fixed charges would be paid for out of assessments, and the annual maintenance budget would be proportionally relieved, thus municipalities would have money to spare out of their annual budget to purchase more or better lighting service, or otherwise improve the efficiency of their systems.

This situation has been recognized by the public utilities companies and the report of the Street and Highway Lighting Committee of the National Electric Light Association presented at San Francisco in June, 1925, contains the following pregnant passage: "The investment in ornamental systems is high. Keep the annual rate down by having the city or property owners pay at least for the posts and fixtures."

The Public Service Company of North-

ern Illinois in a recently published Service Manual of Street Lighting, crystallizes this thought in the following requirements for customer-owned street lighting systems to be connected to and served from their lines:

"A. The customer shall furnish the entire installation.

"1. For an ornamental street lighting system including the lighting units, lamps, lighting standards, underground cables, transformers, time switches and the constant-current street lighting regulators for supplying constant current from the company's existing constant potential distribution system.

"B. Repairs and maintenance expense to be borne by customer.

"1. The customer shall bear the expense for all repairs and replacements for an ornamental street lighting system, excepting the renewal of incandescent lamps, the cleaning of globes, and the patrolling of the system, including winding and setting time switches.

"2. If the customer desires the company to do the actual repairing and maintenance of posts, globes and all other appurtenances thereto, the customer shall pay for such repairs and maintenance at the company's standard rates for time and material.

"C. Repairs and Maintenance Expense to be borne by company.

"1. The company shall bear the expense for renewals of burned-out or otherwise defective incandescent lamps, and shall clean the lighting unit glassware and patrol the lighting system to insure the prompt replacement of burned-out or otherwise defective incandescent lamps.

"D. The company shall furnish all electrical energy.

"1. For lighting the lamps of all sizes, types and burning hours specified by and contracted for by the customer. No other electric lighting service shall be used by the customer on the same installation in conjunction with the company's service, either by means of a throw-over switch or any other connection."

These requirements form a very complete guide for the municipality desirous of promoting an ornamental street lighting system under the third plan.

In the older communities, particularly in the East, the ornamental systems are usually financed under the first plan, and, in consequence, the size of lamps as a general rule is comparatively small. On the other hand, in the newer and more progressive communities of the Middle West and Far West, plan number three is more commonly used. As a result, much larger lamps are in service because the annual budgets are not depleted by fixed charges on a large investment, and thus the municipality has more money to spend on extending its street lighting service and in improving its quality.

The other plans for financing street lighting system have been included to make the picture of the various methods complete, and they may be used should local conditions warrant. In general, however, plan number one is recommended for utilitarian street lighting, and plan number three for ornamental.

In this paper I have endeavored to show the truth of the statement used as the title solely from the standpoint that well lighted streets invariably enhance the taxable value of adjacent property. I have not touched upon any of the other aspects of effective and well-planned street lighting, such as increased safety, diminished traffic congestion and a reduction in crime. Any one of these might readily have been used to substantiate the axiom that street lighting pays for itself.

RECENT DEVELOPMENTS IN ACTIVATED SLUDGE PROESS OF SEWAGE TREATMENT

By Walter C. Roberts, Director of Pacific Engineering Laboratory, San Francisco, Calif.

(An address at 1926 meeting of the League of California Municipalities as reported in "Pacific Municipalities.")

The early history of the activated sludge method of sewage disposal credits two American investigators, Black and Phelps, with doing the first experimental work on the aeration of sewage in 1910. In 1912 the Massachusetts State Board of Health at Lawrence, Mass., conducted laboratory experiments by aeration of sewage in gallon bottles, and later in a small tank. The chief result of these early experiments was to prove that aeration of sewage had a marked clarifying effect and to greatly stimulate scientific interest in this method.

Dr. Fowler in Manchester, England, began experiments in 1913 and was the first to show the real value of mixing previously aerated sludge with fresh sew-

age. Bartow and Mohlman at the University of Illinois in 1915 conducted somewhat similar experiments. The city of Milwaukee started investigations in 1914 under direction of Hatton and Copeland. The subsequent work at Milwaukee has contributed much to the present knowledge of the activated sludge process.

A few years later the city of Chicago started on a 250 million dollar sewage disposal program and established a large experimental laboratory. A million dollar experimental plant was built where different types of equipment and methods of sewage disposal could be studied under actual working conditions.

Two other cities have carried on extensive experimental work in connection with their activated sludge plants, Indianapolis, Indiana, and Houston, Texas.

Several European countries have carried on investigations on sewage disposal but in the field of activated sludge studies, England has the lead of other foreign countries. The English investigators have evolved new types of plants, three of which will be described later. They also use types of screens and other equipment not seen in this country. The cities of Manchester, Birmingham and Sheffield have conducted the most extensive investigations.

In Canada, particularly in the Province of Ontario, there have been several installations of activated sludge plants, mostly in small cities. These plants are reported as operating successfully but there is a scarcity of data on their efficiency and operation costs that makes comparison with other plants difficult.

In California, the City of Pasadena, together with adjoining territory, built an activated sludge plant which was largely modeled after the Milwaukee plant. Lodi has an activated sludge plant of a similar type to the Pasadena plant. The principal difference is in the method of sludge disposal. Another plant has recently been constructed at Pomona. The only other plant in operation in California is at the Folsom Prison.

The U. S. Public Health Service has just completed a plant at the Grand Canyon, which is a very complete small plant. After filtering and chlorinating, the effluent meets drinking water standards.

Taking up now the different types of construction, we find that the usual design for activated sludge plants consists primarily of four units. First, some method for removing the coarser materials in the sewage; second, aeration tanks; third, a clarifier; and fourth, some arrangement for sludge disposal. Provision is also made for the return of a certain amount of sludge from the clarifier to the raw sewage entering the aeration tank.

The removal of the coarser materials eliminates substances which would require long periods of aeration and gives an influent entering the aeration tank which contains only finely divided substances. This removal is accomplished by the use of bar screens and grit chambers followed either by the use of fine screens or by sedimentation basins. Bar screens consist of iron bars placed from a half inch to an inch apart and remove the large solid particles from the sewage. The grit chambers consist of broad channels in which the rate of flow of the sewage is reduced to about one foot per second. These grit chambers follow the bar screens and remove gravel and other heavy solids.

Several types of self cleaning fine screens are in use which will give a satisfactory influent for the aeration tanks. It has been found that rotating cylindrical screens with short bevelled slots of not less than one-sixteenth of an inch in width give good results. This type of screen is preferred to a mesh screen. There is a tendency toward the choice of screens with a minimum of mechanical devices. Rotating cylindrical screens are used at Pasadena and Lodi. The use of settling basins for removing coarse solids is gaining favor. These have a smaller operating cost but larger initial cost than screening plants and take care of maximum flow conditions more easily. The use of Imhoff tanks as settling basins provides for the digestion of the settleable material and offers an opportunity to return the excess activated sludge there for final digestion and de-watering. Dorr clarifiers are used as settling basins at the new North Side plant at Chicago. An Imhoff tank is to be used at the new Pomona plant.

The period of detention in the settling basins and in the Imhoff tanks is the same and varies with the nature of the sewage. It is usually about one hour.

In the aeration tanks there are two principal methods of maintaining aerobic conditions in the sewage, one by agitation with air and the other by agitation with mechanical devices.

The aeration tanks for air agitation are rectangular with wide variations in di-

mensions, being built from 12-20 ft. in width, from 70-300 ft. in length and from 7-16 ft. in depth. Air agitation is usually accomplished by forcing air under pressure through porous plates laid in rows at the bottoms of the tanks. The compressed air is furnished by power blowers capable of about 10 lbs. pressure. The pressure necessary is but little more than that sufficient to force the air through the plates. The plates occasionally become partially clogged, requiring greater air pressure and may eventually need to be replaced. The air for the blower is filtered through air filters to remove any substances that would clog the plates. There are two general types of aeration tanks, the "ridge and furrow" and the "Manchester or circulating." The ridge and furrow type has the rows of plates perpendicular to the length of the tanks, each row being separated from the next by a ride. The ridges prevent the settling of the sludge other than over the plates, where it is caught again in the rising current. The area of the porous plates is from one-fifth to one-tenth of the surface area of the liquid. This type of tank is in use at Pasadena and Lodi.

The Manchester or circulating type of tank has the plates arranged only along one longitudinal side of the tank which arrangement, with the aid of sloping baffles at the top and bottom, produces a rotating motion of the liquid. This method requires fewer plates, slightly less air, and mixes the sewage and sludge more thoroughly than in the ridge and furrow type. There is also the advantages of cheaper construction, lower power costs, and cheaper upkeep. The circulating type of tank is used at Manchester, England, Indianapolis, Indiana, and will be used in the huge new North Side plant at Chicago, and in the new Pomona, California, plant. The amount of air required depends on several variable factors, but is usually about 1.5 cubic feet of air per gallon of liquid treated. The Lodi plant has an enviable record in being able to use what is probably the lowest amount of air per gallon of sewage of any plant keeping authentic records. During most of the year the air consumption is reported at from 0.6 to 1.0 cu. ft. of air per gallon of sewage.

The detention period for the sewage in the aeration tanks is about six hours for both the "ridge and furrow" and the Manchester tanks.

The sludge which is returned to the incoming sewage, is frequently reaerated or "reconditioned" in separate aeration tanks before it is used. These reconditioning tanks are usually similar in construction to the other aeration tanks. All conveying channels for both fresh and treated sewage are usually built with porous plates in the bottoms to permit a constant aeration and to prevent the settling out of solids which might start septic action.

Experiments with the air diffusion type of plants indicate that oxygen is most rapidly dissolved from the air as the bubbles break on the surface of the tank and dissolves much more slowly as the bubbles rise through the liquid. The main function of the rising bubbles is therefore to agitate and mix the sewage and the added sludge. It seemed possible that some mechanical method of mixing and surface aeration could be found that would be as successful as air diffusion and easier and cheaper to operate. This has resulted in the manufacturing of different devices for this purpose. At least two of these are worthy of description.

A plant at Sheffield, England, circulates the sewage through narrow and comparatively shallow parallel channels arranged like cross baffles. Paddle wheels in each channel give the sewage an undulating motion similar to that seen in the water behind a stern wheel steamer, the wheels also give the liquid the same frothy appearance. The speed of the current is sufficient to prevent settlement and the length of the channels such that the undulating motion is continuous. This type of tank is claimed to be economical and successful but has not been widely adopted. There is no plant of this type in operation in the United States.

The "Simplex" type of mechanical aerator consists of an upright iron cylinder approximately 12 ft. long and 2½ ft. in diameter. This is set on legs in the bottom of a hopper bottom tank with about a 6-in. clearance, which permits a free circulation of the liquid into the cylinder. Over the cylinder but not attached to it, is a revolving inverted cone about 5 ft. across, the upper side of which is fitted with curved blades on edge. An opening is cut in the inverted apex of the cone the size of the cylinder. The cone is about the level of the liquid and throws it out in a spray drawing it up from the bottom of the tank through the cylinder. When the spray strikes the surface of the liquid, additional agitation is secured. The cone is driven from a power unit by a shaft which can be extended to run a series of aeration units. This type of plant has given satisfactory results exper-

imentally in Chicago and Decatur, Illinois, and under operating conditions in a small city in Texas, and a unit is to be installed in California this year. The Simplex system has been installed in several British disposal plants and is being installed in a few American cities.

The clarifier following digestion makes it possible to decant the clear liquid and collect the sludge. Plain basins with steep hopper bottoms are used, but flatter bottoms with a mechanical device for scraping or squeegeeing the sludge to the center such as used in the Dorr clarifier, are more commonly found. The period of detention is from one to four hours.

The collected sludge contains 98-99.5 percent of water and is easily handled by air lifts, pumps, or some type of ejector. A portion is returned to the sewage influent and the remainder to the sludge disposal system. The amount of sludge found necessary to return to the aeration tanks for best results varies from 12-25 percent of sludge by volume. This amount can only be determined by experiment and is usually about 20 percent.

The satisfactory disposal of the sludge produced by the activated sludge process offers, perhaps, the biggest problem found in such plants. The sludge from the clarifiers is a brown flocculent mass of organic matter of high bacterial content. It is slow to dry on sand beds, does not filter easily, and is difficult to handle in artificial driers. Efforts to get it into a form that can be readily sold as fertilizer, have not met with much success without excessive costs. A large amount of work has been done at Milwaukee, Chicago, Houston, and elsewhere in an effort to make this an economic possibility. Various mechanical filters have been tried in an effort to get sludge in a condition in which it can readily be dried. The treatment of the sludge with various chemicals such as sulphur dioxide, sulphuric acid, alum and ferrous sulphate has been tried in hopes of increasing its rate of filtration and has met with varying success. It is found that sludges from different sewages react differently under the same treatment. In the arid and semi-arid regions of the Pacific Coast it is likely that sand drying beds will be successful. This method has been used with goods results at Lodi. The sludge must be placed in much shallower depths than would be used with Imhoff sludge. The method of sludge disposal in use at Indianapolis and Houston is to pump the sludge to large lagoons. The lagoons are usually under-drained. The sludge decomposes and partially dries with some odor and is flushed into a nearby stream during high water. Another method is to use the sludge for direct irrigation on agricultural land. Perhaps the most promising method is to digest the sludge, after mixing it with the coarse material taken out by preliminary treatment in Imhoff tanks. This not only offers a method for disposal of the coarse material but dewaters the sludge so that it can be more readily dried on sand beds. This causes the loss of some of the fertilizing value and greatly increases the initial cost of the plant. Researches have indicated that two or three times as much sludge capacity is required as is necessary in an Imhoff installation without activation.

The use of activated sludge plants as a preliminary treatment for sprinkling filters offers a promising future. The effect is to relieve the load of the filters, thereby increasing the filter capacity. Surprisingly large increases are possible in the dosage applied to the filters by the use of only limited detention periods in the aeration tanks. This makes it possible to supplement sprinkling filter systems with standby activated sludge units for use during peak periods. These periods of high flow are common in California as in resort cities having a large seasonal fluctuation in population, and in cities with seasonal industries such as canneies and packing houses.

The sanitary disposal of the trade wastes from many industrial plants is one of the biggest problems of the sanitary engineer. The advent of the activated sludge process and its application to trade waste problems, has opened up a new field for investigation. It is found that some of the wastes can be successfully treated by this method if mixed with domestic sewage, but not if treated separately without excessive costs for chemical precipitation. This again, is a problem which varies with individual plans and must be solved by local study of each particular trade waste.

There is no doubt but that the trade waste problems of many cities could be solved by properly designed activated sludge plants and that further studies will perfect methods for the treatment of wastes not a present successfully treated.

The comparatively high operating and maintenance cost of activated sludge plants has been one of the main objections to their adoption. The mechanical types show a power economy and require less labor attendance. So far data on the

depreciation charges for this type are too meager to warrant any definite conclusions. It would seem that some form of mechanical aeration eventually will be found that will be the most economical form of activated sludge plant, especially for small installations.

The initial cost of an activated sludge plant is no greater than that of other methods giving as high grade an effluent.

The higher operating cost of activated sludge plants over other methods is due to more mechanical devices, higher power costs and a greater labor overhead. The cost per million gallons including depreciation, interest, labor, power, etc., has been found to run from $20 to $50 in the few plants where data is available. The initial cost of the plants vary from $10 to $30 per capita.

The wide variation in these cost figures serves to emphasize the fact that each municipality has a separate sewage disposal problem of its own and that cost data of other cities may not be at all applicable. Thorough preliminary investigation is necessary to economically design a sewage disposal system, whether it be an activated sludge plant or one of the other types. High operating, repair and alteration costs of many plants are directly due to a lack of preliminary investigations.

In closing I want to sum up the advantages of the activated sludge method of sewage disposal:

First—There is but little offensive odor or fly nuisance.

Second—A plant can be built on a comparatively small area and near the city if necessary.

Third—The effluent can be easily chlorinated and as it contains dissolved oxygen, it throws no burden on the receiving stream.

Fourth—The effluent has little or no harmful effect on fish or other marine life.

Fifth—The method is particularly adapted to the treatment of sewage containing trade wastes.

Sixth—A sludge of relatively high fertilizing value is obtained.

Seventh—The effluent is well adapted for irrigation of any agricultural crops. It also contains nitrates and mineral salts of appreciable fertilizing value. Where water costs are an important item as in many California communities, it is an economic waste not to use the large volume of water that could be made available by such sewage treatment plants.

The advantages of the activated sludge method of sewage disposal here outlined would seem to more than counterbalance any increased cost over other methods and should result in its increased popularity.

BUILDING HIGHWAYS FOR SAFETY

By Professor S. S. Steinberg, University of Maryland.

(Recent radio address from Station WRC at Washington, D. C.)

The present is pre-eminently the age of individual transportation. There are to be found on our highways today more than twenty million motor vehicles, sufficient in number to supply one to each family in the United States. It is predicted that in seven years we will have one vehicle to every four persons, sufficient to furnish one to each individual that is old enough to reach the steering wheel. We travel about unhampered by fixed schedules, at speeds that annihilate time and space, and are limited only by the physical condition of our roads.

Although we are improving our highways at a rate never dreamed of before, we cannot keep pace with the demands created by the enormous increase in vehicles. Last year alone, more than 4 1-3 million motor vehicles were produced, an increase over the preceding year of 20%. During this period about 40,000 miles of highways were surfaced, an increase of but 11%. It is then evident that we are producing and absorbing motor vehicles twice as fast as we are providing roads upon which they may conveniently travel. This condition has brought about a traffic congestion on our streets and roads so acute that we have come to realize that one of the major problems facing the country today is to provide sufficient road and street capacity to permit safe operation of our vehicles. Our highway transportation system has been the means of bringing to each of our citizens advantages of an educational, social and economic nature such as are enjoyed by the people of no other nation.

The enormous increase in traffic on our limited mileage of improved roads, coupled with the ever-increasing speed and weight of motor vehicles, has meant not only a great economic loss, but has resulted in a steady increase in highway accidents, taking a toll in human life and property damage so great as to arouse

public opinion to a demand for more extensive highway improvement to keep abreast of motor vehicle registration. The demand is for roads so built and maintained as to permit quick and safe transportation at all times. Likewise, highway engineers now realize that safety is as important as engineering and economics in the design and operation of our highways.

As evidence of this development we might cite that the American Road Builders' Association, the largest organization of highway engineers, road contractors and road machinery manufacturers in the country, has selected as the chief topic for discussion at its next annual meeting the matter of highway safety. This meeting will be held at Chicago, during Good Roads Week, from January 10 to 14, 1927. It is the opinion of the members of this organization that safety on the highways will be best promoted by building wider roads; by a more extensive improvement of our secondary roads, thereby relieving the main highways of considerable local traffic; by properly posting warning signs where traffic hazards cannot be eliminated; and, finally, by securing the adoption of a uniform traffic code in all the states.

Road builders are making every effort to build safety into the road rather than depend upon warning signs and devices alone to protect the motorist. Many state highways departments, as for instance Maryland, Connecticut, and Pennsylvania, as well as a number of large cities, are making a careful study of the causes of accidents occurring on their highways, and are thereby enabled to remedy unsafe conditions. Accident records are kept by means of a highway map on which a colored pin is inserted at the spot on the map where an accident has occurred. A different colored pin is used for each type of accident. An accumulation of pins shows in a graphic manner the location where a construction change is needed.

In the interest of safety, highway engineers are relocating the main roads to eliminate curves, to avoid grade crossings, and to reduce steep grades. Incidentally, these relocations save distance, avoid costly bridges and mean large benefits to the motorist in the cost of vehicle operation. For instance, in Illinois a road 150 miles long was relocated almost entirely throughout its length, thereby saving 30 miles of unnecessary distance and eliminating 31 grade crossings. The saving in vehicle operation to the citizens of that state, as a result of this improvement, is estimated at one million dollars a year. Again, relocating the road from Kansas City to St. Louis, a length of about 300 miles, saved 41 miles in distance and eliminated 15 grade crossings, with an estimated saving in vehicle operation to the citizens of Missouri of $100,000 a year.

The frequency of highway accidents resulting from traffic congestion has demonstrated not only that we must construct our new highways of ample width, but also that we need to widen many of the roads and bridges now in use. This has led to the construction in the vicinity of large industrial centers and on main thoroughfares of what is known as the "super-highway" to insure the maximum road capacity, speed and safety. It is only by widening our congested roads, and by providing alternate routes, that accidents can be reduced and traffic enabled to move smoothly, quickly, and with a maximum degree of safety. Foremost of the super-highways is the one out of Detroit. This road has a total width of 204 ft., with two separated roadways 44 ft. wide, each carrying one way traffic. On each of the four-track roadways horse-drawn traffic keeps to the right hand curb; slow moving heavy trucks outside them, and automobiles in the two other lanes, thereby providing rapid, safe, and easy movement for all kinds of traffic. In addition, space is provided between the roadways for rapid transit trolley lines, and provision is made for motor parking, as well as for pedestrians. Other highways on which extensive widening programs are going on, or parallel routes are being extended, are the Pacific Highway in the State of Washington; highways out of Chicago; the Lincoln Highway west of Philadelphia; the Boston Post Road between New York and New Haven; as well as roads leading out of Cleveland, Akron and Cincinnati.

One of the developments of the future may be separate roads for freight and for passenger service; a low grade, heavily constructed road for trucks and a less expensive type for passenger vehicles. A road planned primarily for trucking between Boston and New York is now under construction.

To relieve traffic congestion and to promote safety at the intersection of important roads, highway grade separations are now being planned. The first structure of this kind is now being erected just north of Chicago at a very congested highway intersection. The design pro-

vides for two levels. Through traffic proceeds on an overhead bridge on one of the roads while turning traffic swings wide of the bridge and uses the ground level.

Traffic congestion, as well as a large proportion of accident cases, may be charged to the slow-moving vehicle. As the speed of the vehicle materially affects road capacity, it is possible that one of the developments of the future in the interest of safety and highway efficiency may be a penalty for not maintaining a minimum, as well as for exceeding a maximum speed.

Statistics show that more than half the motor vehicles in the United States are owned and largely operated in urban communities of 5,000 population and over. When in addition to the local traffic, all through non-stop traffic is also made to pass down "Main Street," congestion must result. This condition has forced the attention of large communities to the desirability of routing through traffic around the edge of the town rather than into the business district. In Philadelphia, a belt line has been provided for routing through traffic around the edge of the city; while in Delaware the DuPont highway, which extends the entire length of the state, avoids passing through built-up sections.

One of the most recent experimental developments in the interest of public safety is lighting the rural highway of night. The greatest menace of night driving is the abundance of glaring lights which makes driving at such times dangerous. It is found that a large percentage of highway accidents occur at night due to this cause. Lighting the highway not only reduces this danger, but also increases the capacity of the road by making it available for maximum use throughout the 24 hours of the day, and serves as an inducement for trucks to operate at night when passenger traffic is at a minimum. Highway illumination is now in use between Albany and Schenectady, on the Lincoln Highway in Indiana, on the motor causeway out of Miami, and on some roads out of Detroit.

An important step to promote highway safety was recently taken by the United States Bureau of Public Roads in cooperation with the state highway departments in adopting uniform standards for warning signs to be used throughout the country. The motorist will no longer be confused by a multiplicity of signs of various designs and degrees of legibility. Hazards will be indicated by signs which will be uniform in all states and which will plainly indicate the kind and degree of danger. The new signs make use of a system of different shapes, thereby increasing their value at night. The shape indicates the degree of hazard and if the motorist cannot read the legend the shape will tell him the degree of caution required.

In this system a round sign indicates a railroad crossing; a diamond-shaped sign calls for a reduction of speed, as at a curve or narrow bridge; an octagon indicates a complete stop, or necessity for proceeding slowly with car under control; a square sign indicates a lesser degree of caution than any of the others, such as a school zone or a side road. Twenty states are now actually engaged in erecting these standard warning signs, and the other states have signified their intention of erecting them in the immediate future.

The highway engineer is bringing science to bear upon the solution of the problems of highway safety. Today but a very small percentage of accidents on our main roads can be attributed directly to engineering defects. No public work is of greater importance than that of widening and extending our present roads, as well as paving new ones to meet our constantly increasing need for adequate highway facilities. Every effort is being put forth by the highway engineer and the road builder, with the limited funds at their disposal, to make the public highway a safer and a better place upon which to ride.

LAKE ERIE AS A PUBLIC WATER SUPPLY

By Howell Wright, Director of Public Utilities, Cleveland, Ohio

(Read before the Central States Section of the American Water Works Association, Sept. 21, 1926.)

Lake Erie is manifold in its blessings —commerce, industry, shipping, recreation. It is a local, interstate and international highway—a public water supply. In this last respect, no doubt, it yields its greatest benefits to humanity. Lake Erie and its tributaries provide water for domestic and industrial uses and for fire protection to at least 25 cities located in four states in this country and to a dozen cities in the Dominion of Canada. The total population thus provided is estimated at about 4,000,000. Less than twenty years ago, water was used by the

population on the banks of the lake in its natural state for many purposes. Today, as a result of the growth of population, of industry and commerce and shipping, it is treated by artificial process by many cities and towns.

Detroit, Wyandotte, Michigan — Sandusky, Vermillion, Elyria, Lorain, Cleveland, Painesville, Ashtabula, Conneaut, Ohio—Erie, Pa., and Lackawanna, Dunkirk, Buffalo, New York, all purify their water supply by the aid of rapid sand filter plants. In Canada, Walkersville and Windsor chlorinate their water supply; Amherstburg has a filter plant; and seven cities, known as the Essev Border Utilities, are soon to have a filter plant in operation.

Lake Erie is the natural drainage body for 25,000 square miles of territory. With its tributaries ,it serves as the natural receptacle for the domestic sewage and trade wastes of a population in excess of four million. This population is increasing rapidly and it is believed will continue to increase.

For many years this dual use of the lake by advancing civilization presented no serious problem. Today the resulting problems are numerous. Rapidly advancing pollution now seriously affects:

1. The lake as a source of public water supply.
2. The sanitary condition of public and private bathing beaches.
3. Property values on the shores.
4. The fishing industry.

Far less attention has been given to prevention of pollution by trade wastes and domestic sewage and to its control than to purification of the water after pollution.

Sandusky has a sewage disposal plant which is not in use. Cleveland has partial treatment in two lake front plants and one plant for complete treatment being built on the Cuyahoga River. Ashtabula has a rough screening and chlorination plant. Lackawanna, New York, has settling tanks and contact beds. Of the larger American cities, Detroit has no sewage treatment works; Buffalo has none; Erie has none and Toledo has none. Practically nothing, taking the territory as a whole, is being done by way of sewage purification on Lake Erie and not much more by way of sewage treatment.

Location of Water Intakes and Sewage Outfalls

The location of water intakes and sewage outfalls in the same body of water presents interesting and complicated problems. It shows at a common sense glance how closely related are the problems of water purification and sewage treatment on Lake Erie. The solution of one to a marked degree depends upon the solution of the other.

In the smaller cities, water intakes are usually only a few thousand, and sometimes only a few hundred, feet from the shore. Cleveland's intakes are 4 to 4½ miles from the shore. On the Detroit and Niagara Rivers (inlet and outlet to lake) the intakes are necessarily quite close to the shore. It is well known that in some localities water intakes and sewer outfalls are in too close proximity.

Old Theory of Location

It is interesting to note in going over the history of the struggle to secure an adequate supply of pure water in this region how plans have been suggested (and tried out) for the control of community wastes through the location of sewage outlets so placed as to pass the "benefits" of the pollution on to the next community neighbor. All will agree, I am sure, that this day has gone forever.

It is indecent for a community to pollute its water supply with its own sewage; it is an interstate insult to pass it on to your bordering state neighbor and, since Lake Erie is an international waterway, it is inconsistent with the principles of international comity to allow uncontrolled pollution of either shore or boundary waters.

The Inter-Relation of Water Purification and Sewage Treatment

State and local authorities have given some recognition to the dangers of community domestic sewage and trade wastes. Its menace to the public water supply has been minimized, however, in the past and is so minimized too frequently now. The problem has been considered largely from the point of view of a nuisance—the dangers likely to accrue to persons living on polluted streams or lakes and to bathers on public bathing beaches. Sewers and sewage disposal and treatment are even now considered as having little or no relation to the publice water supply. Slowness in the development of the sewage treatment art and "tradition" are largely responsible for this. In this connection, I commend to your attention the timely paper by George A. Johnson, consulting engineer of New York City, in a recent issue of the American City magazine on "Sewage Purification—Real and Delusive." We

have already had too much "delusive" sewage purification on Lake Erie.

The facts, however, as to Lake Erie, if considered sanely, will convince anyone, who is willing to be convinced, that the menace to the future water supply of Lake Erie is such as to call for statesmanship of the highest order in its solution. Regardless of "tradition" and custom, it must breathe a new spirit which emphasizes the fact that the problems of water purification and sewage treatment are inseparable and must, therefore, be solved together.

The Cleveland Situation

Let me illustrate what I mean by the situation in Cleveland. In so doing, let it be understood that I am not discussing persons or unduly criticising past policies. I am commenting upon policies, the results of which seem to be wholly inadequate for the solution of a great problem. The emphasis heretofore has been wrong. I am using the illustration to advocate the carrying out of a broader community policy locally, but which is fundamental in its application to the lake problem as a whole.

Let me say here that the inseparable problems of water purification and sewage treatment have been fully recognized by City Manager William R. Hopkins. Their joint solution has been emphasized and demanded by him. And with respect to the control of trade wastes, he has accomplished, in two years, more than has been done here in a dozen previous years. In all matters relating to control of sewage and industrial wastes, he has emphasized the public water supply as the first consideration.

In sixty-eight years Cleveland's first water intake (built in 1854) has been moved from 400 ft. off shore to 4½ miles into the lake. A second tunnel has been built also in that time, with its intake located at the same distance from shore. The history of the location of our intakes is the history of the encroachment of our own sewage pollution upon our own water supply.

Cleveland did not filter any of its water until 1918 and not until 1925 (October) did it obtain a 100% supply of filtered water for the metropolitan district. It undertook water purification first and partial sewage treatment last. Like other cities it has not observed the old maxim "an ounce of prevention is worth a pound of cure."

Sewage treatment in Cleveland became a fact in 1921 but only to a limited degree. It was adopted following orders of the Ohio State Department of Health in 1912 to build plants for the purpose of protecting bathers on the beaches and to prevent a nuisance. Cleveland now has two partial treatment plants on the lake front and is building a third plant with complete treatment processes on the Cuyahoga River, 15 miles from the water intakes in the lake. In our westerly plant we remove screenings and grit, provide Imhoff tank treatment and chlorinate during three months of the year. At our easterly plant we remove screenings and grit and chlorinate during three months of the year.

And in what position do we find ourselves? Cleveland has the best water supply in its history, but the problem is to keep it safe by the process of prevention and complete control of its sewage and trade wastes. With us, as with other large cities, much must be actually accomplished in the next five years.

The population is growing; the sewage menace is increasing. We need complete treatment of all our sewage; but we have no land at these two plants for this purpose and can get little except by making it. And we are planning a new boulevard on the lake front which will pass these plants. If it is practical, we must change them into pumping stations and pump our sewage elsewhere back from the lake for treatment. Or we must make the land and provide the most modern and complete treatment that science can devise to protect our water supply, our lake front property and our bathers.

It will be a hard battle. But other cities on the lake are facing and must face the same difficulties. Detroit, Toledo, Buffalo and other cities are confronted with similar situations now. Will they be misled by the traditions of "nuisance" and "bathing beaches" or will they look ahead and do the big thing of conserving Lake Erie as a water supply for themselves, for their neighbors and for future generations? The very excellent report for the city of Detroit by Messrs. H. P. Eddy, John H. Gregory and Clarence W. Hubbell, recommends only partial treatment. Is what they recommend sufficient for the complete protection of their neighbors from Detroit's sewage? Buffalo may not need sewage treatment for its own purposes now. It discharges its sewage "into the Niagara River and its tributary, the Buffalo River." But the city of Niagara Falls, at least, is not thus protected. Detroit and Buffalo are typical instances

of what I mean by the "passing on to your neighbors" theory.

As helpful guides, I recommend to you the studies of the late Professor George C. Whipple (1904), the extensive investigation of the experts for the International Joint Commission on the Pollution of Boundary Waters, and the recent studies of local pollution by J. W. Ellms (1920-1924) and D. E. Davis at Cleveland and Erie, respectively.

Scope of the Problem

This is not a local and state matter only. It has both federal and international aspects. In 1914 there was an investigation by a joint international commission on the pollution of boundary waters. The investigation was limited in scope. Its findings were that the pollution "is very intense along the shores of the Detroit and Niagara Rivers and in the contaminated areas in the lakes. Throughout the whole length of the boundary waters where sewage is discharged from the sewerage works of cities and towns the pollution is most concentrated in the shore waters on the side of the boundary on which it originates. These shore waters, besides being in places unsightly, malodorous, and absolutely unfit for domestic purposes, are a source of serious danger to summer residents, bathers and others who frequent the localities. So foul are they in many places that municipal ordinances have been passed prohibiting bathing in them."

Since then there has been an increase in the population on Lake Erie but the prevention and control of sewage pollution has not developed as the facts would seem to require. This might well again be made the subject of an inquiry which would investigate the shore pollution of the waters of the Great Lakes. I hope this association will so recommend to the proper federal authorities; namely, the United States Health Service or the State Department and Congress.

Federal Investigation

Your attention is also called to the recent investigation and report by the Chief of Engineers of the United States Army on the pollution of navigable waters. Read the statement of the effects of pollution of Lake Erie by domestic sewage and trade wastes upon the fishing industry and draw your own conclusions as to the possible and probable effect upon the public water supply. I will read but one paragraph from page 24 of this report:

"The pollution of waterways affects not only the fisheries therein but also the public health, sports, and various forms of outdoor recreation. The waters are used by the general public for domestic commercial, industrial, recreational and other purposes. They have been used for the disposal of domestic and industrial wastes since the settlement and industrial development of the United States began. What constitutes the highest and most economic use of a waterway aside from its use as a public highway of commerce is a problem the solution of which involves a study of local conditions and the proper adjustment of the various conflicting interests of the locality. The growth and industrial development of a locality may depend upon the use of its streams for economical disposition of its domestic and industrial wastes; and should the pollution of streams in such a locality be prohibited, the future development of the section might be seriously impaired. As a general rule the value of the products of the fisheries is small as compared to the total value of the products of all the industries which use the waters for other purposes. The problem, therefore, resolves itself into a determination of the use of each waterway which will result in the greatest benefit to the community. It is believed that should the federal government undertake the control of pollution generally there might be a tendency on the part of the state and local authorities to relax their efforts to study the problem and to enforce the local laws, with the result that the entire problem would be left to the federal government, which would be confronted with the necessity for providing a large organization to cope with the many local problems which would arise."

It is plain to be seen that unless the local and state authorities exert themselves to a greater degree in these matterms of stream and lake pollution, we will eventually have the federal government dealing with it. The intervention on the part of the federal government may be in the interest of industry and commerce at first but it will have its effect upon the water supply and the public health.

The Duty of This Section of the American Water Works Association

This section (the Central States section) of the American Water Works Association should take an active interest in these inseparable problems of water purification and sewage treatment as related to Lake Erie.

1. We must understand that we are

not concerned solely with the mechanics and hydraulics of water supply. We have something else to think of besides pumps and mains and reservoirs. We water works officials are concerned with the big problem of obtaining an adequate supply of pure water for all purposes for our respective communities.

2. This means (and especially so where sewage outfalls and water intakes are within the same body of water) that we must be constructively concerned with:

a. The prevention and control of pollution by trade wastes.

b. Adequate and modern methods of sewage treatment and real purification.

c. Filtration and disinfection of the water used by the public.

3. We must not hesitate to discard if necessary the old traditions of sewage treatment and make the art fully effective as applied to the protection of our natural waters from sewage and trade waste pollution.

4. We must watch state legislative proposals affecting trade wastes, sewage control and the public water supply. Legislation intended for rural counties but having state wide application may be very injurious to the interests of large cities or communities confronted by exceptional conditions.

5. We must try to do our part in insisting that engineers of state departments having authority over matters pertaining to sewage and water in our cities, and especially lake cities, are fully awake to the importance of these problems. State departments that do not recognize and emphasize the relation of sewage pollution to water supply, especially as regards Lake Erie are not alive to the true significance of the situation.

6. We must wake up. We must see that the fundamental principles of conservation are applied effectively to Lake Erie and that the precious heritage of this public water supply is guarded and protected and made safe for ourselves, for our neighbors and future generations.

STATE STREET LIGHTING, CHICAGO

State Street, Chicago's main business thoroughfare, will be the world's brightest white way when its new lighting units are installed. There will be approximately 1,800 lumens per lineal foot of street, more than 100 percent more than the most intensive street lighting system which has been installed up to this time. Seventy specially designed ornamental Union Metal standards are to be placed in the loop district. Two fixtures, equipped with 2000-watt lamps, will be mounted on each standard with the light center nearly 28 ft. above the sidewalk. The standards, arranged on both sides of the street and opposite each other, will be approximately 100 ft. apart.

The system, operating on a 110-volt, direct-current, three-wire system, will be remote controlled from a central point with a number of magnetic contactors located along the system. In most instances there is a contactor for each pole, but in some locations one controls two or three poles. The contactors are connected to a three-wire control system operated from the 220-volt side. All three wires are positive, each contactor being connected to the negative side of the Edison three-wire system.

All the lamps will operate until 1 o'clock. At that time some of them will be turned off, the others remaining lighted through the night. Alternate standards will remain lighted so that a balanced effect will be maintained.

PORTLAND CEMENT ASSOCIATION APPOINTMENTS

The Portland Cement Association announces the following appointments in its general office staff effective October 1:

C. R. Ege, manager, Advertising and Publication Bureau, succeeding H. C. Campbell, resigned.

G. S. Eaton, assistant manager, Advertising and Publications Bureau.

W. E. Hart, manager, Highways and Municipal Bureau, (formerly Highways Bureau).

F. R. McMillan, manager, Structural and Technical Bureau, (formerly Ctructural Bureau).

T. J. Harris, manager, General Education Bureau.

Mr. Ege is an associate member of the American Society of Civil Engineers, has served as treasurer and is now president of the Highway Industries Association. He has been with the association for 10 years, and manager of the Highways Bureau since 1920.

Mr. Eaton has been with the association over six years prior to which was a member of the staff of the Associated General Contractors. He was at first on

the staff of the Highways Bureau and has been prominently identified with the publicity and publications features of the association's work.

Mr. Hart is an associate member of the American Society of Civil Engineers and is prominent in the affairs of the American Concrete Institute. He has been with the association nine years and for four years has been manager of the Structural Bureau, after having served three years as district engineer at Minneapolis.

Mr. McMillan is a member of the American Society of Civil Engineers and has been associate engineer with the research laboratory of the association for two years, prior to which he was engaged in consulting engineering at Minneapolis. His contributions to engineering literature are widely known, particularly through the American Society of Civil Engineers and the American Concrete Institute.

Mr. Harris has been prominently identified with the advertising activities of the association for six years. He has had newspaper experience of note and is identified with numerous organizations in the journalistic field.

FEATURES OF NEW WATER FILTERS AT NEW ORLEANS

By John L. Porter, Purification Director, New Orleans, La., Water Board

(From a paper before the latest annual meeting of the Southwest Water Works Association.)

There are some distinctly new ideas which have been developed in connection with the design of the new work, of the New Orleans Water Purification Plant, and which I will bring out a little later. First I will outline the main feature of the extensions to the Carrollton purification plant at New Orleans, with some description of modifications in design, which have resulted from nearly seventeen years of experience in operating the two water purification stations of the Sewerage and Water Board at New Orleans.

Operation and maintenance of existing works, and the design and construction of new works, in each department of the board's activities, rests with the forces of that department, under the supervision and guidance of its general superintendent and chief engineer. In this way those who have had to do with the operating conditions are in position to apply the knowledge and experience gained whenever extensions or new work is to be undertaken.

The Original Plant

The original plant of a nominal capacity of 40,000,000 gals. daily, partially softens, coagulates, and filters the Mississippi river water, furnishing a clear, palatable, relatively soft water of a high degree of bacterial purity.

This plant is located at the extreme upper end of the city, about three-quarters of a mile back from the river. Two 48-in. suction lines extend from the intake at the river to the low-lift pumps at the plant, being laid below extreme low water throughout its entire distance. These pumps deliver the raw water to the entrance chamber of the headhouse, or chemical house. From here the water passes to and through one of the grit reservoirs, which measure each approximately 75 ft. wide by 320 ft. long, 19 ft. deep, and of a nominal capacity of approximately 3,000,000 gals, when filled to a depth of 16 ft. From the grit reservoirs the water passes back through the headhouse through adjustable orifice gates which regulate and control the chemical treatment of the water, to one of two lime mixing reservoirs on the opposite side of the building.

Lime Mixing Reservoirs

These lime mixing reservoirs are each approximately 75 ft. wide by 340 ft. long, divided into two tiers of 8 passages each, about 8 ft. square, through which the water moves with a minimum velocity of not less than one foot per second. From the lime mixing reservoirs the water again passes through the headhouse and out through upper passages in a 4-passage wall to the coagulating reservoir.

There are four of these reservoirs, two on either side of the passage wall, so arranged that each pair may be used in series, or all four or any number of them may be used in parallel. These reservoirs are approximately 250 ft. wide by 350 ft. long, 12 ft. deep, and have a capacity of 7½ millions each, giving a total coagulating capacity of 30,000,000 gals., when all reservoirs are in use and all clean, and provide 18 hours nominal settling capacity. These reservoirs have a baffle lengthwise the reservoirs and located midway between the side walls.

Two Clear Water Storage Reservoirs

There are two clear water storage reservoirs of 7½ million gallons capacity each, built entirely of concrete with a groined arched roof and earthed over.

These reservoirs are partially below the general ground level and partially above and are connected to the clear water well of the high-lift pumps by a 48-in. line through a balanced valve, which will automatically open to allow water to flow by gravity from these reservoirs into the well whenever the level of the water in the well drops below a predetermined level.

Ten Filter Units in System

From the coagulating reservoirs the water passes back under the headhouse over to the filter gallery. There are ten 4,000,000-gal. filter units located five on either side of the pipe gallery. From these filters the water passes through effluent controllers into the equalization reservoir beneath the filters and from here the water passes through a 5½-ft. concrete channel to the clear water well at the pumping station.

From here the water is taken by the high-lift pumps and delivered directly into the distribution system. The original installation of high-lift pumps consisted of four 20,000,000-gal. vertical triple expansion Allis Chalmers pumps, which maintain a pressure of 75 lbs. at the pumping station. Within the last year and half there have been installed two single stage high-lift centrifugal pumps, motor driven, with a capacity of 40,000,000 gals. each to a pressure of 75 lbs., or 30,000,000 gals. each to a pressure of 100 lbs. These pumps were designed by Mr. A. D. Wood, mechanical engineer of the sewerage and water board.

The treatment of the water at New Orleans consists of treatment with lime for removal of the temporary hardness which is carried practically to the limit of solubility of calcium carbonate. The incrustants or permanent hardness has not been considered sufficient to justify the use of sodium carbonate for its removal, although the original design provided for the soda treatment. After the lime treatment the water is coaglated with sulphate of iron to precipitate the mud and organic matter including bacteria.

As the water leaves the equalization reservoir in its way to the clear water well it is treated with chlorine.

Pumps Must Deliver Water to Distribution System

New Orleans being a very flat city, there are no high spots on which to build a clear water storage reservoir, which can equalize the demand for water and therefore the high-lift pumps must deliver water into the distribution system to supply their widely varying hourly demand for water and to maintain a constant pressure on the water as delivered to the mains. This necessitates the operation of thewhole plant on a variable flow of water basis, and pumps, filters, and chemical treatment must respond to this ever changing demand.

The maximum rate probably approaches twice the average daily rate and three times the minimum daily rate. During the year 1924 the average daily consumption in New Orleans was approximately 45,000,000 gals. During the month of August, 1924, the average daily consumption was 52,000,000 gals, with maximum day peaks of round 60,000,000 gals. and hourly peaks as high as 75,000,000 gals. per day, so that the necessity for extension to the purification plant is very apparent.

Extensions to Filters First Started

It was only in February, 1924, that funds were available to start construction on these extensions, and work was actually started about the first of March of that year.

While in was recognized that early increase in capacity of all parts of the plant was necessary and complete duplication at an early date, it was felt that earliest relief could be obtained by increasing the filter and equalization capacity. For this reason work was first started on the extensions to the filters.

As stated before ,the original filters consisted of five 4,000,000-gal. units located on either side of the pipe gallery, giving with gross dimensions of approximately 160 ft. by 150 ft., including the filter gallery. The new installation is to consist of eighteen 4,000,000-gal. units, ten of which are to be arranged alongside the existing ten filters on either side of a pipe gallery, and eight 4,000,000 units located opposite the end of the old and new ten-unit groups with a cross gallery connecting the old and new 10-filter group galleries.

Some Unusual Problems of Construction

New Orleans and the surrounding territory are located on an alluvial deposit, built up by the Mississippi river. The soil consists of clay, mixed with varying proportions of sand, more or less decomposed vegetable matter, roots, and stumps, and is continually shrinking as the soil becomes dried out more completely by the installation of sewerage and drainage. Subsidence of from 6 ins. to 1½ ft. of the soil in places in the more

developed parts of the city have occurred, and in the newer reclaimed portions of the city settlement of the soil of from 1 to 3 ft. has occurred following drainage. All structures resting on the soil settle somewhat, and all heavy structures must be placed on piled foundations which are driven to sand strata located 40 or more feet below the general surface. The soil will not withstand any appreciable side thrust which may be developed on structures supported on piles, and provision must be made of any tendency to lateral movement of such structures. The original filter installation was built on piles. The equalization reservoir floor was of the inverted groined arch type of construction, partially reinforced, and the roof of the equalization reservoir, supporting the filters, was of the groined arch type. For this reason it was realized that great care must be taken in building the new filters alongside the old filters in order not to cause any tendency to lateral movement which might endanger the existing structures.

Piles to the number of approximately 3,000 were driven over the entire area to be covered by the new filters before any excavation was started, and on the end of the settled water passage trenches were excavated to below the level of the bottom of the equalization reservoir and concrete beams were put in extending from the base of the old settled water passage to the steel sheeting which had been driven around the site of the excavation, in order to prevent any lateral motion of the existing structure. The base of the new equalization reservoir, as well as its roof, was of the flat slab type of construction fully reinforced.

At the present time the concrete work for the equalization reservoir, under the 18 filters, has been completed and the side walls and interior walls of 5 more filters have been built, together with the major portion of the piping for the 8-filter group. One filter has been completed and has been in operation for about four months.

Grit, Lime Mixing and Coagulating Reservoirs

Early this year work was started on the construction of the new grit reservoirs, lime mixing reservoirs, and coagulating reservoirs. These are located approximately southwest and west of the existing reservoir system. There will be two grit reservoirs of approximately the same width as the original grit reservoir but nearly twice as long. The lime mixing reservoirs are to be two in number approximately 80 ft. in width and 600 ft. in length, each divided into eight passages approximately 10 ft. wide. There will be four coagulating reservoirs approximately 350 ft. by 400 ft. in size, providing about 75 per cent greater capacity than the original installation, which will give a total increase in capacity of about 175 per cent.

In the new grit reservoirs the baffle will be located centrally in the reservoirs as in the original construction; but in the new coagulating reservoirs the baffles will be located so as to provide about twice the area in the incoming side of the reservoir over the outgoing side. This is believed to provide more economical operating conditions at New Orleans as past experience has shown that fully 90 per cent of the suspended matter precipitates in the first part of the incoming side of the reservoir, but due to its fluidity distributes itself quite uniformly over the entire half of the reservoir.

Duplication and Interchangeability Considered

In designing the extensions to the existing plant it has been the aim to provide not only ample increased capacity but a duplication of the existing plant so that when the additions are completed the old plant can be put out of service for much needed inspection and repairs necessitated by the local soil condition.

Provision has also been made to operate any new plants interchangeably as far as possible, and for this reason operating levels and flow lines of old and new work have had to coincide. The new grit reservoirs will be supplied with raw water from the present low-lift pumps at the plant, but it is planned that pumps will be eventually installed close to the river, using the present suction lines as discharge lines.

There will be two Venturi meters located in the passage between the grit reservoirs and the lime mixing reservoirs, which will measure the water entering the plant and control the chemical feed to the water by means of proportional flow diaphragm controlled apparatus designed by Mr. Earl.

New Chemical House to be Provided

There will be a new chemical house in which provision will be made for the mechanical handling of chemical from the car to the solution tanks. In one end of this building will be located eight steel storage bins of cylindrical section, 20 ft. in diameter and 20 ft. high, with conical bottom, which will provide storage for

approximately 20 carloads of lime and iron. At the other end of the building will be located the chemical solution and feeding equipment. Bucket elevators and screw conveyors will carry the chemicals from the car to the bins or to the daily feed hoppers located above the chemical solution tanks, or from the storage bins to the daily feed hoppers. From the feed hoppers the chemicals will be fed through weighing machines to the slaking tanks in the case of lime and to the solution tanks in the case of the iron sulphate.

From the solution tanks the chemical solutions will flow through chemical controllers controlled by a proportional flow regulated by the Venturi meter on the incoming water.

In the new reservoir system all baffles and skimmer walls which rest on the floor of the reservoirs, which are not supported by piles, are to be constructed of wood, as the settlement of reservoir floors, which has been considerable, and not uniform, makes it very difficult to maintain concrete baffles in good alignment.

More Central Location for Mud Pump

In the original plant mud was removed from the various reservoirs by means of a centrifugal pump located at the front end of the headhouse. During the first twelve years of operation of the plant this mud was pumped on to vacant land beyond the existing reservoirs and an accumulation of some 250,000 cu. yds. of mud has resulted. For the last four years the mud has been pumped directly back to the river.

In the new installation the mud pump will be located more centrally to the whole plant, at the intersection of the four new coagulating reservoirs.

This mud pump will be of the same size and type as the pump now in use, but will be provided with a larger motor to take care of the greater friction head resulting from pumping to the river. The new discharge line will be 20 ins. in diameter instead of 18 ins., which was the size of the original line. This pump has a capacity of approximately 8,000,000 gals. per 24 hours.

Duplication of Wash Water Facilities

In the original filter installation the filters were washed by water, stored in wash water tanks, supported on the roof trusses of the filter gallery, these tanks being filled from the high pressure distribution system. In the new installation duplication of wash water facilities is being provided by the installation of a wash water pump located in the new 8-filter pipe gallery and connected with the wash water piping system of the new filters which in turn is looped around and connected to both ends of the main wash water line of the old filters. This pump has its suction arranged to take water either from the equalization reservoir or from the clear water reservoir, and its discharge arranged to deliver water into the wash water line or the wash water tank or to deliver water from the equalization reservoir back into the clear water reservoir. This latter arrangement provides a duplication of the existing pumping arrangements in the pumping station for filling the clear water reservoir, which is rendered advisable by reason of the use of this pump for circulating condensing water to the 6000 KW steam driven turbines located in the power house.

Due to the greater length of the wash water lines in this loop arrangement to enable the use of the wash water pumps in connection with the new filters, the size of the main piping was increased from 24 ins. in diameter to 30 ins.

New Underdrain or Strainer System

Probably the most radical change in filter construction is in the type of underdrain or strainer system. The filter bottom at New Orleans, as in many other plants constructed at about that time, consisted of laterals formed in concrete above the filter bottom which were covered by perforated brass plates and were fed through eight bellmouths which connected with a cast iron pipe distribution system beneath the bottom of the filters in the equalization reservoir. Above the strainer plates in valleys formed by concrete ridge blocks was placed an 8-inch layer of graded gravel covered with bronze screen cloth bolted to the top of the ridge block.

In plants where water softening is carried out the periodic changing of the gravel layers which become concreted by the deposition of lime and magnesia the difficulty and expense of this work, as well as the initial cost of this type of filter bottom, lead to the consideration of a type of construction which would be equally efficient in wash water distribution, less difficult to maintain and less expensive to construct if possible. The pipe grid system of underdrain as used in some plants, while having some advantages did not appear to provide uniform sufficient distribution of wash water.

A type of underdrain has been developed by Eugene Delery, assistant engineer on design, which it is felt meets the requirements to a greater degree than any existing type of strainer system.

This underdrain system consists essentially of a main conduit formed of concrete at the bottom of the central gutter of the double filter units, with curved branches of cast iron which are imbedded in the concrete at the bottom of this passage, the axis of which make an angle of about 40 degrees with the axis of the conduit and the inlet opening of which conforms to the curvature of the conduit. These bends terminate in bells which are flushed with the outer walls of the passage. Into these bells are leaded brass tubes of 4¼ ins. outside diameter made of No. 20 gauge brass, and closed at the far end. In the bottom of these tubes are perforations made by a special machine which cuts the metal of the tube and depress it, forming an indentation which projects into the tube against the flow, producing the effect of a pitot tube introduced into a flow. There are two rows of perforations in each tube spaced 3 ins. apart in each row, giving eight perforations per foot of tube, which are spaced on 1 ft. centers throughout the end of the filter unit.

The advantage of this type of underdrain is that it enables the construction to be entirely above the bottom of the filter, takes up a small amount of head room, gives a uniform distribution of wash water, and costs very considerably less than the original type of underdrain ($1,500 to $2,000 less per 4,000,000-gal. unit.)

Experimental Filter Shows Efficiency

In an experimental filter of 1,000,000-gal. capacity using 2¼-in. tubes an efficiency of 99 to 99½ per cent of distribution was obtained with wash water rates of 6 to 8 times the normal rate of filteration, and in the first of the new 4,000,000-gal. units where the perforations were made somewhat larger in order to utilize the relatively low available head of the existing wash water tanks before the completion of the wash water loop line an efficiency of 95 percent was obtained.

In the original installation Earl controllers of the balanced float type, regulated by a master controller, governed by the level of water in equalization chamber, which in turn is dependent upon pumpage, were used. The new controllers will be of the Venturi type controlled by equal pressure diaphragms which have been developed by Mr. Earl.

This type of controller not only governs the rate of filtration but serves to measure the flow of each individual filter as well as the total output of all filters governed by the master controller.

To save room and simplify piping as well as reduce cost somewhat hydraulicly, Venturi valves will be used as effluent valves. All valves are so placed that they will remain in their normal operating position should pressure water for any reason be shut off from the hydraulic cylinders.

New Type of Sand Adopted

The sand used in the original plant was a beach sand obtained from Horn Island, an island in the Mississippi sound about 100 miles from New Orleans. This sand had an effective size of .35mm., and a uniformity coefficient of 1.65. This sand is relatively expensive and attempts were made to find a cheaper sand which would be equally satisfactory. A bank sand of approximately the same effective size and uniformity coefficient was obtained and put into two of the filters and conditioned by washing repeatedly and then scraping off the top layer. The results of operation with this new sand indicated that due to the presence of relatively small amounts of very fine sand which are not completely removed by washing and scraping much shorter runs between washing were obtained, and the more expensive Horn Island sand is justified in giving more economical operating conditions.

INFLUENCE OF MOTOR BUS ON LAND VALUES

By C. W. Courtney, Engineer, Cleveland, Ohio

(From a recent issue of "Realty Record.")

It seems needless to dwell upon the relation between transportation and land values. This relation, or the thought that other things being equal, the better the transportation facilities the greater the land values, is so thoroughly fixed in the mind of everyone as to be almost axiomatic and yet these land values, while extremely sensitive to public opinion once attention has been focused on a particular territory, are far less sensitive to actual and fundamental changes. The public generally has become accustomed to startling accomplishments and to revolutionary changes and are inclined

to accept extravagant predictions along any line without serious question, possibly with the thought that unwillingness to accept them marks the hearer as narrow or lacking in vision. And yet if the prediction had been made a very few years ago that transportation facilities which had served a given district for years and had perhaps been one of the prime factors in its development could be abruptly removed without serious results to the community so served, this prediction would probably have found few ready to accept it. This, however, is what has taken place and is still taking place in the removal or the discounting of service on many interurban electric lines.

That this can take place without serious results is due in part to privately owned automobiles but to aconsiderably greater extent to the ease with which the motor bus fills the place left vacant by the electric car. In fact the coming of the motor bus was the straw which finally brought disaster upon many of the struggling traction companies which had brought their territory almost to a paying basis only to find their antiquated equipment discarded by the riders in favor of the newer and in some cases more popular mode of transportation.

As to the effect on land values, this is of course variable depending upon numerous other conditions and upon the facilities which are offered to replace those of the traction line. Where no service has been offered there has no doubt been a corresponding slump in land values, but there are on the other hand cases where values have actually increased in spite of the removal of the traction line.

Cuyahoga County, Ohio, has recently witnessed the discontinuance of service on two of what would a few years ago have been considered important traction lines, one of these lines extended easterly from the County line tapping a large territory in Geauga County. In both cases the service was taken up immediately by more or less satisfactory motor bus service. In one case land values along the route of the former line have increased at an abnormal rate, due however to influences which followed very closely upon the abandonment of car service. On the other line there have been no unusual conditions to offset the removal of transportation service, except for the fact that acreage values throughout the County have been increasing, but here also land values have increased and there has been no indication that the development of the territory has been seriously retarded. This condition has been brought about by the fact in the first instance that the factors entering into the increase in land values was pretty well understood by those who cared to inform themselves regarding them, while in the second case there was a considerable population whose comfort depended upon the satisfactory working out of the transportation problem and the very solving of the problem brought to them those things which eventually spelled an increase in land value. These sections have prospered and advanced because public attention has been directed towards them and because it is evident that their problems have been or are being solved. There is, however, a great territory between and beyond these two lines which by the discontinuance of the traction service became as accessible so far as the remaining means of transportation is concerned as the territory which had grown through the monopoly produced by the selection of that route for an interurban line. It is true that the territory which had previously been served had acquired a certain momentum so far as the development of the land is concerned, which momentum must be overcome by the other territory before it is on a par with it.

Land values, so-called, except for a very small percentage which may be established upon an earning basis are a matter of more or less composite opinion. So long as the public generally or a considerable number of the larger investors believe in one territory over another, the land in that territory will have higher so-called value. It is likewise true that transportation is not the only factor entering into the desirability of land and consequently its value for any given purpose. It is true, however, that around the large centers of population practically all of the land is sooner or later absorbed for one purpose or another and while individual parcels or districts may vary greatly as to value and may travel different routes and at varying speeds so far as value is concerned they all travel pretty much in one direction and that direction is influenced to a large extent by matters relating to transportation. If changes are made in transportation either in the facilities which actually exist or in the more fundamental matters affecting methods or ability to serve, these changes

will affect actual land values and these actual land values must eventually prevail. These changes may affect to a less degree the immediate so-called values because attention may have been centered upon some particular feature or upon some particular territory and because no real analysis had been made of the new conditions. There are great areas around Cleveland which have been affected by the fundamental changes in transportation methods. These values are affected less by distance in miles than by time in minutes. Suitable highways into a territory having been provided this territory is potentially in as favorable a position as any similarly situated, even though one may then have adequate motor bus facilities. The newer territory must acquire the momentum which the older has attained through the existence of actual service but the difference in so-called land values between those districts which are ready for service and the territory to which public attention has been directed because of existing service is greater than the difference due to the potential and actual facilities.

The motor bus can never replace rail transportation as a whole but it will continue to replace those lines where the public can be better and more economically served. Street car lines, interurban electric lines and especially so-called rapid transit lines are an essential part of any large community but these lines tend to increase the possibilities of the motor bus by providing new centers from which this type of service may radiate. Good roads, motor cars and motor busses are changing the character of many communities and are establishing new values and new standards of value.

POPULARIZE TRAFFIC REGULATION

The traffic problem has outgrown individual judgment, avers Earl J. Reeder, staff engineer of the National Safety Council, who declares rules and regulations are not necessary because the average man is less desirous of preventing accidents than formerly but because the average man is incapable of deciding just what is the safe procedure in the midst of a large number of vehicles moving in different directions.

Mr. Reeder writes:

"The traffic problem has outgrown individual judgment. It has developed so rapidly that, left to their own choice, individuals are entirely incapable of deciding just what is the safe procedure in the midst of a large number of vehicles moving in different directions. Left to exercise his judgment independently the individual has to decide whether his acts in traffic will fit in properly and safely with the acts of hundreds of other drivers and pedestrians who may be affected by it.

"It is for this reason that traffic control has to be established at certain points as the traffic flow becomes denser. It is, likewise, for this reason that left turns have to be prohibited at certain intersections as traffic increases. Similarly, the time comes when safety zones have to be provided for patrons of the street car company. Vehicles are prohibited from entering such zones although they are located in the street where vehicles formerly traveled. All of these and many others are instances of the vast increases in the complexity of the traffic problem beyond the point where individual judgment is able to fully cope with the situation.

"Placing a legal restriction upon the wilful acts of careless drivers and heedless pedestrians is not the only purpose of traffic rules, regulations and control although this is, indeed, an important one. They are not alone for the heedless, the reckless and the criminal minded, they are likewise, for the careful and the law abiding people who want regulations and rules of conduct as well as direction for their movement at individual locations, to determine for them what, on the average constitutes safe procedure in the use of the streets.

"What, then, shall constitute the scope of education in traffic safety? What needs to be instilled in the minds of the users of the streets? Is it the development of the individual judgment alone? No. Above all, the users of the streets, both motorists and pedestrians, must be taught to conform to regulation. They must be taught what the traffic regulations of their community are and why they should be obeyed. In other words, traffic regulation must be popularized. It must be shown to be a public necessity and not a needless restriction.

"Careful citizens must learn that traffic regulations supplement their normal good judgment and make it safer to use the streets. They must realize that to be effective traffic regulation must be voluntarily observed, whether under direct

police supervision or not. They must learn that it is not a restriction imposed merely upon the heedless and careless but must be borne by the careful as well, regardless of their individual ability. It must be held up as a safe-guard and guide to those who recognize the need for care, but must mingle with thousands of others, some less careful than they are in the use of the streets.

"To obtain the support of those who are normally safe drivers and consider themselves as such the supervision and administration of traffic regulation must be dignified, businesslike and fair. Nothing will destroy the effectiveness of traffic regulation more quickly than an undignified, partial, or careless administration and supervision of it. Consequently, the administrative authorities have a great deal of responsibility in instructing the general public in traffic regulation. Courteous, yet firm and impartial, administration of the traffic rules and regulations among those who will receive it as such and voluntarily act upon it is quite as important as 'bawling out' the wilful violator and 'giving him a ticket' if he talks back.

"Agencies for the education of the general public in traffic safety can render their biggest service by directing their emergencies largely at popularizing traffic regulations and the observance of traffic rules and control. The vast majority of the general public wants to know what are the governing rules and regulations, just what they mean, why they are needed, and just how to observe them.

"If people do not read traffic regulations understandingly and willingly, steps should be taken to make them more inviting and to encourage a proper understanding of them. One by one the important features of a traffic ordinance should be taken up, given general publicity in newspapers, club meetings and such other means as the individual community affords, so that a proper understanding will be assured.

"Then we must deal with the wilful violator. Some, seeking special privilege and with little regard for the rights of others and the safety of themselves, will not voluntarily respond to an effort to popularize traffic regulations. For public safety they must be required to abide by the safe practices on the streets which have been adopted by the majority through education. The problem here is one of rigid enforcement. To meet the needs of this group, the supervision and administration of the traffic regulations must, likewise, be firm, businesslike, and performed without prejudice.

"All of this, of course, assumes ordinances, rules and regulations, as well as methods of traffic control, that are up to date and workable. They must be wholly consistent and thoroughly practical and must meet the community needs. From time to time, consequently, these governing rules of traffic conduct should be revised and supplemented to bring them up to date. Otherwise, they cannot be successfully enforced and cannot form the basis for a comprehensive educational program on traffic safety.

"In general, if the traffic regulations conform properly to the needs of the community they can be made the basis of the traffic safety educational program, the purpose being to popularize them and to encourage their voluntary observance. If, on the contrary, they do not meet the requirements of the community the first important job is to get them revised in such manner as will make them properly enforceable and worthy of the respect of the community. In either event, the educational program must center largely around the problem of proper regulation in all of its various phases."

PAVEMENT RECONSTRUCTION STUDIES IN CALIFORNIA

By C. S. Pope, Construction Engineer, California State Highway Department, Sacramento, Calif.

The studies necessary for a proper investigation of pavements which it is proposed to reconstruct have been given attention by the Construction Department and some of the features entering into the problem are presented herewith:

1. Grade and Alignment Survey

It is usually desirable, though not always necessary, that a grade and alignment survey with the necessary cross sections should be made. If grade and alignment surveys show that an extensive destruction of old pavement will result or if the original line will be deviated from seriously the economic comparison of pavement types may be extensively modified; as may also the condition survey hereinafter mentioned.

Surveys should give grades and cross sections of the old pavement with sufficient accuracy to determine the amount of surface material in tons or cubic yards which will be required.

Curves which do not conform to present standards for either horizontal or vertical curvature should be studied and reconstructed where necessary.

Superlevation needs to be provided for in most cases as a considerable amount of former work is lacking in proper super-elevation.

Grade in excess of three or four percent of excessive curvature is usually considered a condition adverse to asphaltic types of surfacing, though recent developments in pavements of this type should make a change in sentiment in this regard.

2. Condition Survey

Before deciding upon a pavement type for reconstruction over old paving a condition survey of the old pavement should be made.

In the case of an old stone or macadam or bituminous macadam road, if the same is on the proper grade, an accurate determination of the thickness of road should be made by digging through the road metal at intervals of not over two hundred feet.

Cuts should be made through the crown and at each quarter point and the thickness recorded.

If old concrete is to be resurfaced it should be examined and classified at suitable intervals in accordance with the Bureau of Public Roads classifications which are as follows:

Class A—Normal number of transverse cracks but no longitudinal cracks.

Class B—More than normal number of transverse cracks and some corner breaks.

Class C—Similar to A and B but with longitudinal crack and a considerable number of corner breaks.

Class D—Tranverse and longitudinal cracks so numerous as to break pavement into slabs less in area than Class C but not less than 50 square feet.

Class E—Cracks so numerous as to break pavement into slabs less than 50 square feet in area but no general disintegration.

Class F—Badly broken and with disintegrated paving.

If the old concrete has been surfaced, the surface should be removed at intervals for a width of one foot across the entire width of the pavement in order to properly examine the base.

It is generally assumed that a concrete pavement in Class C condition or better, may be successfully surfaced with asphaltic concrete from 1½ to 2½ ins. minimum thickness.

Paving in Class D or Class E condition may sometimes be saved with asphaltic concrete surfacing from 2½ to 4 ins. in thickness, although additional concrete base construction is considered better practice, except on the best foundation soils.

Paving in Class F condition usually requires complete reconstruction, though sometimes it may be saved by use of second story concrete.

3. Economic Traffic Study

An economic study of pavement types is impossible without a proper traffic census, a knowledge of the first cost of various types of pavement and accurate information as to the cost of maintenance of each type. Formerly this information was not available, but under our present methods of recording information, the various factors required for a proper solution of this problem will be available with increasing accuracy each year.

If we are able to establish accurately certain factors the economic trend of the problem of comparison of types is quite simple, and may be reduced to mathematical solution.

4. Soil Survey

It is now common practice to make a soil survey even for reconstruction work.

Both alkali and adobe soils have been found adverse to concrete pavements and require treatment before such pavements are laid. Sandy soil is particularly favorable to croncrete pavements.

Asphaltic concrete and macadam are not affected by alkali, but require special base construction to be entirely satisfactory on adobe soils.

Among other matters which should be given consideration, in addition to the above mentioned matters of major importance, are the following:

Make a survey of road building materials available and establish availability of material and plant suitable for different types of construction.

Report prevailing weather conditions and usual amount of wet weather which might be unfavorable to any particular type of paving.

Consider and compare following constructions:

(a) Flush shoulders of concrete.
(b) Asphalt Macadam surface and shoulder.
(c Asphalt Concrete surface and shoulder.

(d) b and c with Portland Cement Concrete shoulders.
(e) Sheet Asphalt in combination d.
(f) Second story concrete.

Compare the consistency of recommended construction with that used in other parts of the State under similar conditions.

FROM THE ABOVE BRIEF OUTLINE IT SHOULD BE APPARENT THAT SOUND PRACTICE DICTATES THAT CONCLUSIONS AND RECOMMENDATIONS FOR THE TYPE OF CONSTRUCTION TO BE USED SHOULD BE REPORTED WITHOUT REGARD TO PERSONAL PREFERENCE AND OPINION BUT IN ACCORDANCE WITH AN ECONOMIC AND ENGINEERING ANALYSIS BASED ON DESTRUCTIVE TRAFIC TO BE CARRIED BY THE PARTICULAR ROAD UNDER INVESTIGATION.

CULTURE VERSUS ENGINEERING EDUCATION

By G. S. Wykoff, Purdue University, Lafayette, Indiana.

(From "Engineers and Engineering" for September, 1926.)

The engineer today is a specialist. At the same time he is intensely practical. Everything that he does, that he reads, that he thinks, even that he dreams, must have an application which must further practically the work on which he is engaged. There is no place in his life for spiritual things, for things of beauty, of appreciation, of culture, and there is no time, even in his hours of recreation, to devote to the enjoyment of literature, art, or music. He can only exist; not live; he can only earn, not enjoy.

The cause of all this is readily apparent, for it is the attitude the engineer adopts at the very beginning of his preparation for his profession—the attitude of specialization which unfortunately, at this stage of civilization in America, is the predominant one in all professions. In some of these, like that of the lawyer, the teacher, the minister, and the artist, cultural things are acquired naturally, as a part of one's preparation. But the case of the engineer is different. From the day he has chosen his life work—usually in high school or at the very beginning of his college term—he feels that he must specialize intensely, that the need of his profession is great and the time of his preparation is short, and that everything with the least tinge of impracticability, with the faintest coloring of spirituality, is to be shunned like a hideous disease. He can be made to study subjects if he can be shown they are practical and will lead to the advancement of both himself and his profession. But if the subject is one whose content is only to be appreciated, to be enjoyed as a thing of beauty, then the engineering student closes his mind like an oyster its shell, and he remembers only enough of this necessary evil to make a passing grade in the course.

A natural consequence is that the engineer is quite ignorant of any subject that lies outside his own immediate field. I have been teaching engineering students for several years, and each succeeding class seems to make more apparent this attitude of narrow-mindedness and practicality, this neglect and ignorance of cultural things which help to make life beautiful. True, my students have been mostly freshmen and sophomores, but a rather close observation of upperclassmen, and even of young engineering graduates, has served only to confirm the impression.

For instance, not so long ago I asked two of my classes—about sixty sophomores—certain questions about literature. The answers were surprising.

They were asked to identify Carl Sandburg, Hugh Walpole, Vachel Lindsay, Harriet Monroe, John Philip Sousa and Otis Skinner, all of whom had visited the university or the city during the three preceding years. Few identified all correctly, while answers like the following were not unusual: Vachel Lindsay is a German musical composer, a statesman, a historian, an English authoress; Otis Skinner is an American poet; Carl Sandburg is an American cartoonist.

Other questions asked were these: 1. Name six living American poets. 2. Name six living American novelists. 3. Name six living English poets. 4. Name six living English novelists. 5. Name six operas. 6. Name six musical composers (living or dead). 7. What are the Pulitzer prizes?

No perfect papers were turned in, and not many that were anywhere near perfect. In many cases, most of the questions were left unanswered. Zane Gray, Rex Beach and James Oliver Curwood were listed most frequently as the novelists, and Edgar Guest and Robert W. Service as the poets. The few students who had heard of the Pulitzer prizes

knew of them in connection with the airplane races. "The Old Soak" and "The Cat and the Canary" were given as titles of operas.

Not more than ten percent of each class had attended the various musical and dramatic events—few but excellent—at the university or in the city. Six only of the sixty had seen Otis Skinner in "Sancho Panza," and only seven had attended two concerts by an excellent little symphony orchestra.

Most of these students demanded authority for the statement that cultural things are important in an engineer's life. It was not hard to find; in fact, it was in one of their own textbooks. John Butler Johnson (died 1902), a practicing engineer and later Dean of Engineering at the University of Wisconsin, in an address, "Two Kinds of Education for Engineers," said in part: "The one crying weakness of our engineering graduates is ignorance of the business, the social, and the political world, and of human interests in general. They have little knowledge in common with the graduates of our literary colleges, and hence often find little pleasure in such associations. . . . For your own personal happiness, and that of your immediate associates, secure in some way, either in college or after leaving the same, an acquaintance with the world's best literature, with the leading facts of history, and with the biographies of many of the greatest men in pure and applied science, as well as of statesmen and leaders in many fields. . . . This kind of knowledge, also, elevates and sweetens the intellectual life, leads to the formation of lofty ideals, helps one to a command of good English, and in a hundred ways refines, and inspires to high and noble endeavor. This is the cultural education leading to appreciation and enjoyment man is assumed to possess."

Engineering students are fair-minded. When they speak frankly, they admit that literature, music and art are good things, that they should like to know more about them, but that most of their time is needed for their own special engineering subjects, and what little time remains they spend in other kinds of recreation.

Now, is such a condition deplorable and undesirable? Many will say no, others yes. Some of us feel that there are many good things in life—cultural, it is true—which the engineer is missing, and which he really cannot afford to miss. We realize there is not time even for a cursory study of music, painting and literature, and we turn to the last-mentioned as possessing the highest cultural value of the three, believing the general definition that "Literature is life." We think that an engineer can, should and would appreciate such gems of poetry as Shelley's "To a Skylark" or Browning's dramatic monologues; that he would enjoy some, not all, of the older novelists; and that the better modern dramas and better musical comedies would and deserve to appeal to him more than such insipidities as "Getting Gertie's Garter" or "Parlor, Bedroom and Bath."

Our universities are making only a feeble attempt to remedy matters, although the assumption is safe that even a concentrated effort would not meet with much success. In English, for example, there are few elective courses, because there is no demand for them, and the required English courses have bowed the knee to the god of practicality. A study of the curricula offered at our various technical universities shows these things plainly, as a few examples will indicate:

At Purdue University there are four required semesters of English: three of them are practical, two being English composition, the third public speaking. Of the elective courses, those in business writing and in public speaking are the most popular. Elective literature courses are almost wholly neglected by the engineering students. At Massachusetts Institute of Technology a combined course in English and history is required, the first two years; during the last two years, four terms of general study subjects are required, chosen from a varied list grouped under these headings: Social, Political, Economic and Business Subjects; Literature, English, History and Fine Arts; Science and Foreign Literature. At Cornell University one year of English composition fulfills the engineering requirements. At the University of Illinois engineering students are required to take only one year of English, this work consisting of rhetoric and themes. And at the University of Michigan, of the 140 hours of credit work required before the degree of Bachelor of Science in Engineering is conferred upon a student, only six hours need be in English.

There is a tendency now current to shorten the engineering courses and make them still more practical and intensive. If such a plan is adopted, un-

doubtedly the subjects of study eliminated will be the so-called impractical and unnecessary courses in English and literature, and after them perhaps history and the languages.

These, then, are the conditions at present. In the future will there be a more favorable attitude on the part of the engineer towards spiritual and cultural things, or will culture, in its broad sense, and engineering education continue to be almost diametrically opposed?

GRADE CROSSING ELIMINATION PLANS IN WISCONSIN

By J. T. Donoghey, State Highway Engineer, Madison, Wis.

(From "Badger Highways" for August, 1926.)

A number of conferences between representatives of the Wisconsin Highway Commission, the Railroad Commission, and the chief engineers of the principal railroads operating in the state have been held with the view of working out a plan for cooperation between the state and the counties on the one hand, and the railroad companies on the other, which would bring about a steady program of railroad grade crossing elimination in the state of Wisconsin.

The public generally recognizes that the development of the motor vehicle and the use of the highways have proceeded faster than the highways have been improved. In order to keep pace with the demand for more and more surfacing, the funds available for highway purposes have had to be expanded for grading and surfacing, and, while the necessity of providing for safety in the way of proper grades and alignment has been recognized, it has been necessary to postpone the carrying out of many necessary railroad grade crossing separations on account of the inability of the railroad companies to adjust themselves to the growing demands.

It is universally recognized that railroad grade crossings are the most dangerous places in the highways. Statistics, which need not be printed here, show plainly that the number of deaths and serious injuries resulting from railroad grade crossing accidents is many times greater than in other highway accidents. It is very seldom that a grade crossing accident occurs without someone being killed. Practically every newspaper contains the horrifying details of accidents of this kind.

When the Highway Commission, about 1919, began its Federal aid construction program in earnest, many of the earliest projects were planned with the view of eliminating railroad grade crossings. Many of our readers must be familiar with highway relocations which removed the highway entirely from a series of railroad grade crossings, thereby eliminating the crossing insofar as the state trunk highway traffic was concerned. A considerable number of grade separations were also constructed. Efforts to cooperate voluntarily in these projects, but without much success, and the greater number of grade separations made were the result of orders from the Railroad Commission.

In justice to the railroads, however, it must be said that these improvements were carried out at a time when the railroads were undergoing the readjustment which followed war conditions, and when they were in bad financial condition, which made it extremely difficult for them to undertake anything in excess of the bare necessities for the operation of their trains. Expenditures for railroad grade crossing improvements would bring in no operating revenues, and the position of the railroad boards of directors and the railroad executives, when asked to contribute substantial portions of the cost of improvements which would not return revenue, can readily be understood.

Under the law, the board of any town, village, or country, the council of any city, or the Highway Commission, in cases where the highway adjacent to the railroad crossing is to be improved with funds expended under its supervision, may bring an action before the Railroad Commission for a separation of the crossing by other means. When the action is brought, the Railroad Commission is obliged to hold a hearing and investigation to ascertain the facts, and, after such hearing and investigation, it may order the improvement that it deems most appropriate to the circumstances, and may apportion the cost between the interested parties; but the railroad companies have the right, if they so desire, to appeal any order to the courts, and in this way it is possible for them to postpone over extended periods improvements ordered by the Railroad Commission.

During the period between 1919 and

1925 the Highway Commission brought a number of cases before the Railroad Commission asking for apportionments of the costs of relocations made to eliminate railroad grade crossings, and to secure separations of grade in connection with highway improvements being carried out. Many of the awards of the Railroad Commission in these cases were appealed, first to the circuit court and then to the supreme court, and while all of this litigation was successful in that the orders of the Railroad Commission were sustained (except one case only), the experience is such as to make it plain that much more can be achieved if a plan can be worked out by which the railroad companies will cooperate voluntarily, and the rights of the public will not be sacrificed. The plan finally worked out is substantially as follows:

The Plan

When the Highway Commission proposes an improvement involving a railroad grade crossing, a conference will be arranged between the representative of the Commission and the railroad, and a tentative plan of improvement will be worked out. In some cases this will mean a separation of grades either by means of an overhead structure by which the highway will be carried over the railroad, or by means of an underpass by which the railroad will be carried over the highway. In other cases there will be a relocation of the highway by which the highway will avoid the objectionable grade crossings. When the improvement to be made has been decided, whether it is an overhead, a subway, or a highway relocation, the cost of the project along the route selected, including the grade separation or the relocation from the point where it leaves the old road to where it returns, will be estimated, and also the cost of an improvement of the same character on the existing highway, and over the grade crossing. In this way the increased cost of the improvement made to eliminate or avoid the grade crossing will be ascertained . This increased cost will be apportioned between the railroad company and the public, 60 percent to be borne by the public and 40 percent to be borne by the railroad company.

The laws of this state do not provide any specific basis of apportionment; it shall be as determined by the Railroad Commission, and the Railroad Commission cannot be said to have fixed on any exact basis. Its practice in the past has been to apportion more than 40 percent against the railroad company. These companies have contended, and there is perhaps some logic in their contention, that the apportionments against them have been too heavy. They say that the increased number of accidents at grade crossings is not due to any change in railroad operation, but that it is due to the vastly increased number of motor vehicles which travel the highways. It is true, as everyone knows, that roads which did not carry 25 vehicles per day 20 years ago, now carry 2,500 vehicles per day, or even much more than that. The railroad companies also maintain that a proper exercise of care on the part of the drivers of motor vehicles would avoid all except a negligible portion of the accidents. It must be admitted that there is some justice to this contenion. On the other hand, people are losing their lives at railroad grade crossing every day, and the public demands that railroad grade crossing work proceed at the most rapid rate possible.

The public is interested much more in the amount of work that is being done to prevent accidents at grade crossings than in the exact apportionment of the cost of this work. Furthmore, the railroads claim, again with some logic, that if they are made to pay the cost of railroad grade crossing elimination, whatever they pay must in the long run be paid by the public, and that it would be more logical if this were borne by the public in the first place.

If there is any basis of apportionment that can be considered as being more nearly fair in the average case than any other, it would be to have the apportionable cost paid one-half by each party, fifty percent by the public and fifty percent by the railroad. The apportionment suggested, namely, sixty percent by the public and forty percent by the railroad company, was prompted by a desire on the part of the Highway Commission to be more than fair, hoping that this would induce the railroad representatives to lend themselves more readily to the plan. The Commission believes that the most important thing is to get the crossings eliminated, and it would rather concede something to get cooperation than delay the work in an effort to force the railroad companies to pay a thousand dollars or two more of the cost of each job.

Results of Conferences

Two conferences have been held between the representatives of the most

important railroads in the state, namely, the North Western, the Omaha, the Milwaukee, the Soo Line, the Burlington, the Illinois Central, and the Green Bay & Western, representatives of the Railroad Commission, and representatives of the Highway Commission. In addition, there have been a number of conferences with railroad representatives on definite projects.

The representatives of the Railroad Commission have indicated that they were in favor of more railroad grade crossing work; that the plan proposed by the Highway Commission met their approval. They have also made it clear that the necessity for railroad grade crossing improvements outside of the state trunk highway system would have to be given proper recognition and that reasonable provision for work of this kind would have to be made; in other words, the grade separation work on the state trunk highway system could not be carried out to the exclusion of other necessary work. All of the representatives of the railroad companies present agreed to the proposition in principle. Some of them stated that they might find it difficult to provide as much money for this work as the Highway Commission might deem necessary. The representative of the Burlington, which is a powerful line with but a limited mileage in the state, approved the proposition unreservedly, and the same thing was true of the Illinois Central. The Omaha and the North Western. the latter having by far the greatest mileage of any road in the state and the greatest number of grade crossings, have also informally indicated that they will cooperate fully with the Commission. We feel sure that the other roads will in due time come in to what they consider the extent of their ability.

While no formal agreements have been made, negotiations have been carried out with regard to several important grade separation projects under the proposed plan. The most conspicuous of these is a proposed separation of grades between State Trunk Highway No. 12 and the North Western line between Fairchild and Augusta. A terrible accident, in which three people were killed and one very severely injured, happened on this crossing this summer, and it is particularly distressing because at the time the accident occurred the agreement for the separation of grades had been practically worked out. Another, which is substantially in the same class, is a separation of the grades of State Trunk Highway No. 19 and the Milwaukee road in the village of Sun Prairie. One that is in the process of negotiation is the crossing with the North Western at Fonda, where a truck load of negro laborers was recently struck by a train with several fatalities resulting. It should be noted in this connection, also, that the dangerous character of this crossing was recognized and the negotiations started before this accident occurred.

The important thing for the people of the state to know in this connection is that the authorities in charge of highway work and the authorities in charge of the operation of the railroads both recognize the necessity for a proper program of this character; that the public authorities are unreservedly for it, and the same is true of the railroad authorities, with the reservation that they can proceed only as fast as the funds at their command will permit. The same consideration applies to highway work as well, because the funds available for that purpose are by no means unlimited.

The contemplated program will involve the expenditure of approximately $1,000,000 annually, which, on the basis of the apportionments stated, will mean $600,000 of highway funds and $400,000 of railroad funds. Probably the full magnitude of this program will not be attained immediately, but we have the best of hopes that the program that we have already begun will amount to this in a year or two at the most, and we feel sure that it will be possible, even if we cannot realize it fully, to eliminate at an early date many of the most dangerous grade crossings that remain, and thus save many human lives.

EXPERIMENTAL ROAD IN VIRGINIA

By C. A. Hogentogler, Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

A demonstration highway from which it is expected to obtain information comparable in value and importance with that produced by the Bates Road and Pittsburg (Calif.) tests and the experiments of the Bureau of Public Roads at Arlington, Va., is now under construction between Fairfax and Warrenton, Va. The road, which is being built by the Virginia Highway Commission under the direction of Henry G. Shirley, chairman, and C. S. Mullen, chief engineer, of the

commission, is a Federal-aid project. It traverses the historic Bull Run battlefield and the famous bridge over the run still may be seen by visitors to the demonstration road.

The new demonstration, unlike the previous experimental roads, is not intended as a test of road design or of the relative value of different surfacing materials. The Virginia standard 8-6-8 concrete section, which is used on the major portion of the road, is not in question. Instead the type of information sought concerns a number of questions not covered by the previous tests and relating principally to the influence of the subgrade, the effect of admixtures of various sorts, of the kind and quantity of reinforcement, of various finishing methods, and other details of construction. In general, the type of information sought concerns the economy of various common practices in concrete construction, especially the various measures employed to prevent cracking and breaking and promotes the smoothness of the surface.

In its length of 9 miles the road provides opportunity for the study of the effect of the following variables:

1. *The subgrade.* — Seven different types of soil are represented in the natural subgrade and thin courses of stone screenings and both single and double layers of tar paper have been used as coverings in certain sections.

2. *Construction joints and dividing planes.*—Expansion and center joints are used in only one section. Construction joints are placed at noon and at night. Longitudinal dividing planes have been used in two sections, in one of which transverse dividing planes have also been used. These planes of weakness are formed by installation of a patented type of separating strip about 2½ ins. deep. With the exception of the section containing both longitudinal and transverse dividing planes, which is laid to a uniform thickness of 7 ins., the Virginia design of 8-6-8 pavement, 18 ft. wide, was used in all sections.

3. *Aggregate, cement, and mix.*—The same sand and crushed stone are used throughout the work. Two well-known brands of cement have been used, and the mix is either 1:2½:3½ or 1:2:4.

4. *Admixtures.*—The three admixtures used are hydrated line, 5 and 8 per cent; Celite, 3 per cent; and calcium chloride, 2 per cent; all incorporated.

5. *Types of construction.*—The three types of construction employed are plain concrete, vibrolithic concrete, and reinforced concrete. Both single and double layers of welded steel fabric, bar mats, and expanded metal are used in the latter.

6. *Finishing and curing.*—Part of the road is being finished by hand methods. The remainder is to be machine finished, using both Ord and Lakewood finishing machines. With the exception of the section containing calcium chloride, all sections are to be cured alike by covering with wet earth for 14 days.

Experimental Work

The road on which the demonstration is being conducted is strictly a service highway constructed under State supervision with convict labor. It will not be subjected to accelerated traffic.

The Bureau of Public Roads is cooperating in the experimental work which includes studies of the subgrade, the concrete materials, and the effect of construction operations. The nature of the investigations is briefly as follows:

1. *Material investigation.*—This work, which is carried on at the Arlington Experimental Farm, includes tests of specimens in which either the sand, cement, or stone is varied, and tests, at various ages, of beams made of the same mixes and containing the same admixtures as the road sections. Routine tests and special expansion and contraction observations are being made in the Washington laboratories of the bureau.

2. *Test cylinders.*—Test cylinders made during construction are being cured alongside of the road under conditions as nearly as possible identical with the road slab. The position of batches from which the cylinders are made is marked so that cores can be drilled later. This will allow a definite comparison to be made between the strengths of cores and cylinders from the same batch.

3. *Surveys and construction observations.*—A complete subgrade was made prior to the beginning of construction in the course of which observations of drainage conditions were taken and samples of soil were procured for testing in the laboratory. Subsequent inspections of soil conditions have been made after heavy rains.

Observers stationed on the work are keeping accurate records of all occurrences and practices which might influence the condition of the pavement. Atmospheric conditions, temperature and humidity, and the slump of the concrete are recorded hourly. The time of pour-

ing each batch and the time it is finished and covered is kept accurately and the position of the batch is carefully platted with identifying station numbers indicated. This provides an efficiency record which shows the vibration in the intervals between the three important stages.

Condition surveys of the surface are made before the wet earth covering is placed and after it is removed; and all of the data mentioned are plotted on final record sheets together with the grade and alignment of the road. Future surveys will be made to determine how the surface condition is influenced by the various factors.

4. *Observationsof surface smoothness.*—After the earth covering is removed the relative smoothness of the various sections will be determined by the use of a 16-wheel profilometer. The effect of the surface condition on truck wheel impact will be measured by means of accelerometers attached to trucks; and the effect on the truck body will be measured with a recording roughometer.

Information with regard to the surface smoothness and relative first costs of the various sections will be available immediately. The influence of the various other factors on the condition of the surface can, naturally, be learned only after the road has been in service a sufficient length of time to develop defects.

PREVENTING INCREASE IN AUTO ACCIDENTS

If automobile accidents continue at the same ratio during the next ten years as they have in the past decade there will be 300,000 persons killed between 1925 and 1935, declared Charles E. Hill, vice-president in charge of the public safety program of the National Safety Council, when he spoke at the fifteenth annual safety congress. Mr. Hill presented some recommendations which, if adopted by communities throughout the country, should result in checking automobile casualties, according to safety men who heard his address.

In his address, Mr. Hill said, in part:

"We must not overlook the fact that if automobile fatalities increase at the same ratio during the next ten years as they have during the past decade there will be 50,000 persons killed in this manner during 1935, and more than 300,000 of our men, women and children will have entered the dome of eternal silence as a result of automobile accidents, alone, during a brief period of ten years.

"The cost of highway traffic accidents in the United States is now at least 600 million dollars per year, and this does not include the cost incident to traffic congestion. Upon the same basis as heretofore predicated this cost will soar to one and one-half billion dollars for 1935 and for the next ten years will amount to the staggering sum of more than 10 billion dollars. I am stating cold facts based upon the experiences of the past. Ought not this startling sacrifice of human life be sufficient to insure to our safety program the most loyal and whole hearted support of every man and woman in this country? Is it fair that the innocent suffer due to lack of concerted movement on our part?

"Traffic accidents present a comparatively new problem, but we must remember we are living in a country of progress where we have problems to solve and where we never stop until we solve them. To do so we must have a complete mobilization of community forces. We must have the full cooperation of all organizations and agencies, civic, political and otherwise co-ordinating one with the other, having one purpose only—the conservation of human life.

"In considering the entire matter—accidents of all kinds—we get more and more to the point where we recognize the problem as one for the community. Industries are doing great work individually—yes—but they cannot succeed alone. They need the aid of the public.

"Accidents that come in the other classifications are automatically a problem for the community. Therefore, the entire scheme ought to be considered in an intelligent, comprehensive manner following a definite plan of procedure.

"To carry out such a plan, consideration should be given to three fundamentals:

1. Engineering; 2. Education; 3. Enforcement.

Engineering is used broadly to include:

a. The scientific study of accidents and their causes, etc.
b. Establishing of safe conditions and determining what constitutes safe practices, etc.

Education includes—

a. Information showing causes of accidents.
b. Arousing them as to need for personal carefulness.

"Enforcement means compelling the heedless minority to observe safe practices, which the greater majority have adopted voluntarily through education."

THIN BRICK PAVEMENTS STUDIED

By L. W. Teller, Engineer of Tests, and J. T. Pauls, Associate Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

(Editor's Note: The present article gives the conclusions reached under accelerated traffic tests and field studies of their paving brick by the Bureau of Public Roads as reported in a very comprehensive article in the September, 1926, issue of "Public Roads," issued by the Bureau.)

There has been manifest lately a growing belief among engineers that brick less than 4 ins. in thickness may properly be used in the construction of brick pavements. Advocates of the thinner brick have contended that the 4-in. depth is unnecessary, and that brick of 3-in. thickness or even less would give equally satisfactory results, and the extensive and satisfactory use of 3½ and even 3 in. brick in some parts of the country has apparently lent support to the contention.

If such a reduction in thickness can be made without impairing the service value of the pavement, and if the manufacture of the thinner brick is practicable, the resulting economy in the construction of brick surfaces would doubtless be very considerable; and the question is one which merits thorough investigation on that account. If, as experience has apparently demonstrated, the 3½ and 3 in. thickness can be employed successfully, the investigation should confirm that fact and go further to the extent of ascertaining the least thickness practicable from the points of view of manufacture, service, and cost.

Recognizing the importance of the question the Bureau of Public Roads has undertaken to conduct such an investigation, in the course of which it has made a field study of the service behavior of brick pavements in which brick of less than 4-in. thickness have been used, and concurrently an accelerated traffic test, at Arlington, Va., on sections of pavement built of brick of different thickness and a series of laboratory tests on the brick used to determine their quality. Several plants manufacturing brick of less than 3-in. thickness have also been visited to determine the attitude of the industry toward the use of the thinner brick and to ascertain if their manufacture presents any particular difficulties.

Conclusions Indicated by the Investigation

The several parts of the investigation have now been completed and the analysis of the data obtained seem to warrant certain conclusions, among which the more important are:

1. That 2½-in. brick of the quality used in the Arlington traffic tests, when properly supported, will prove satisfactory for pavements carrying the heavier types of traffic.

2. That brick of 2-in. thickness, when properly supported and of the quality used in the tests, will be adequate for pavements on streets carrying the lighter types of traffic.

3. That a bedding course of plain sand is more effective in reducing breakage of brick than a cement-sand bedding course, the breakage being much less on the former than the latter. The depth of the sand bedding course should not greatly exceed three-fourths inch. Increasing the depth tends to produce roughness in the pavement.

4. That cobbling of the brick is greatly increased as the spacing between bricks is increased.

5. That the use of excessive quantities of asphalt filler is a common and serious fault in construction, unnecessarily increasing the cost and resulting in a condition which impairs both the appearance and the serviceability of the pavement.

6. That base construction of other than the rigid type may in many cases prove entirely satisfactory. Macadam bases and those constructed of certain types of natural earth appear to be suitable when the local conditions are such that these types of construction maintain their stability throughout the year.

7. That no difference in the base construction is necessary for the different thicknesses of brick.

The purport of the foregoing conclusions is almost startling when a quick reading of the official report reveals the terrific pounding given the test pavement starting in November, 1925, and continuing through the winter and spring into May of 1926.

In this period 629,600 tons of truck traffic were applied to this pavement, the wheels of the trucks being confined to

two strips 30 ins. wide painted on the surface.

This tonnage was applied in two phases:

1—40,000 trips with plain tires.

2—22,200 trips with chain-equipped tires.

The individual applications started with a 3-ton truck loaded to capacity and advanced to a 7½-ton truck loaded to capacity.

All of the traffic, therefore, was heavy truck traffic and all of it was concentrated in two 30-in. wheel tracks, so that the abuse was accentuated to the greatest possible degree.

Some idea of what this means in normal highway traffic can be gleaned from the following quotation from the report:

Taking the average of all truck traffic on the Cook County, Ill., highway system, the report says:

"Compared in this way the traffic on the test sections is shown to be equivalent to the average truck traffic using all highways in Cook county in 18 years, and the test traffic of 6 to 7½-ton trucks to be equivalent to the corresponding actual traffic in 70 years."

The foregoing applied only to the plain tired traffic. Regarding that portion of the test in which chains were used, the report, considering that chains are used only a few months in the year, says:

"It will readily be seen that the test traffic with chains was far greater than any that could possibly come on any actual highway during the life of the pavement."

THE SUCCESSFUL SANITARY WATER SURVEY

By Isador W. Mendelsohn, Associate Sanitary Engineer, U. S. Public Health Service, Chicago, Ill.

(From "The Nation's Health for September, 1926.)

Water supplies will always be of great public health importance because of their inherent potential means for spreading disease. With the development of modes of transportation bringing the ends of a country closer together and the opening up of infrequently visited areas, the use and abuse of water will increase. The health aspects of this problem in closely built up areas in the United States are now under investigation. Policies are also being formulated for conservation of water supplies for public and industrial use.

Underlying all public health policies regarding water supplies are the data obtained from comprehensive sanitary surveys. That the sanitary survey is of prime importance in judging the quality and purity of a water supply has been definitely and authoritatively established in the publication of the United States Public Health Service setting forth the new drinking water standards. It is proposed in this paper to present the fundamental requisites for a complete sanitary water survey.

Purpose of Survey

The purpose of a sanitary water survey is to obtain all pertinent information about the supply so that a reasonably accurate judgment may be formed regarding: (1) the present purity of the water; (2) potential dangers existing or likely to develop; (3) the improvements believed necessary to safeguard it against these dangers; and (4) the action considered advisable to obtain these improvements. So interpreted, a sanitary survey will include a careful and thorough investigation and action based on the following: (a) source of supply; (b) physical system; (c) methods of treatment; (d) laboratory control; (e) vital statistics of the community served; (f) organization and statistics of water department; (g) other water supplies in town; (h) report of survey; (i) follow-up action.

The data are obtained from a personal investigation and a careful study of the results of bacteriological, chemical, and microscopical analyses. Everything that may affect the purity of the water used for domestic purposes should be considered. If the water contains iron in such quantities as to discolor clothes in laundering, the people will use other waters, either partly or wholly. That is true, also, where the water is hard, or warm, or turbid, or has a disagreeable taste, color, or odor; where the water rates are high; where the general supply is either insufficient in volume, or where there are frequent power or pump shutdowns; and where there are industries requiring additional water supplies for cheaper fire insurance rates or for certain industrial uses to which the public supply is not adaptable. If the waterworks organization employs incompetent operators, or the system is not kept in good condition at all times, such facts will have a great bearing upon the purity of the water. In case of severe droughts when other water supplies are used it is neessary to investigate them as care-

fully as the main supply. In addition, the availability of water treatment chemically is one of the essential points of a survey. In 1920 when the freight car shortage was at its worst, and in 1921 at the time of a great snow storm in the New England States, many water treatment plants were without aluminum sulphate, liquid chlorin, and other chemicals. As a result, several water borne disease outbreaks occurred.

Of interest and value in connection with satisfactory and unsatisfactory features to be noted in a sanitary water survey is the outline on pages 6, 7, and 8 of Drinking Water Standards. (Drinking Water Standards, Reprint No. 1029, P. H. Reports, April 10, 1925, 28 pages.) Other valuable and more extensive outlines are: Outline of Water Supply Investigations, prepared under the supervision of the Ohio State Department of Health; and Data Relating to the Design and Operation of Rapid Sand Filtration Plants Treating Highly Polluted Waters, prepared by the Office of Water Purification Studies, Stream Pollution Investigations, United States Public Health Service Laboratory, Cincinnati, Ohio.

The first thing to do in making a sanitary water survey is to study all previous reports and correspondence on the water supply concerned. If the information is in such form as to make it possible to carry a copy of the report into the field, the latest report, including bacteriological and chemical data, may well be taken. In addition, the investigator should have readily available for the field general data on water supplies, such as the water consumption, rates and per cent of metered services in various representative American towns and cities; flow of water in pipes; cost of pipe lines, reservoirs, filtration, and other water treatment plants; operation and cost of chlorin machines; application of chemicals to water; typical examples of water borne disease epidemics and losses incurred; and similar information.

Should Have Adequate Maps

It will be of value to have topographic and other maps of the own and surrounding country, and fire insurance agents' maps showing the public water system and other water systems, and indicating cross connections between the public and other waters. Before departure into the field, it is desirable to compile a list of names, titles, and addresses of the various people to confer with in the survey.

Sometimes the water commissioner is the person to see, sometimes the town engineer, sometimes the water works operator, in going over a water supply and obtaining the necessary information. From the very beginning, the investigator must be on his guard to note in person everything affecting the purity of the water. He should see every part of the system, go into the laboratory and study the available data. Frequently, a water works official may pay scant attention to a certain feature, not deeming it of sufficient sanitary importance. On one such occasion in North Dakota, the investigator found that manure placed over the intake pipe to keep it from freezing had become imbedded in river ice just above the pipe. The analyses of the water at the time disclosed B. coli.

It is necessary that the investigator maintain an impartial and receptive mind in making each survey and refrain from easing up in his quest for information when he finds the system is designed by a well known consulting sanitary engineer or under the supervision of a reputable laboratory. It is a fine thing to honor such men and laboratories for their past work, and to study their achievements and methods closely, but it is of the greatest importance to the future of safe water supplies that such respect does not blind the enthusiastic workers of today upon whom will be thrust the responsibilities of providing safe water supplies to the population of tomorrow. Too frequently water systems have been found with insanitary conditions in the light of recent water borne typhoid fever epidemics. As for analyses, every water laboratory differs in technic in one or more respects from the procedure recommended in the new standard methods of the American Public Health Association. Some very well established laboratories in the United States differ so markedly in their technic from recognized procedure as to raise a question as to the value of their analyses.

Reservoirs Often Polluted

Some of the more common and some of the unusual experiences noted on a sanitary water survey are here given. On one occasion in Utah it was found that a picnic grounds and summer camp were located on the drainage area and that fishing was unrestricted. This water supply was inadequately treated with chlorin. In Pennsylvania a survey disclosed that ice is harvested from an impounding reservoir, although the water from the reservoir is being used un-

treated in the city. A Colorado watershed had several surface privies near streams flowing directly to the city's service pipe line, the water being untreated. On many catchment areas grazing of sheep, cattle, and horses is common practice.

In the case of stored waters it was found in a Colorado town that quail hunting is a favorite pastime in the vicinity of open reservoirs, into which the shot quail fell, and from which they were retrieved. In an arid section of Nevada, an open steel reservoir was used in place of the old swimming hole and several boys were drowned in it, not to mention cats. In Yellowstone National Park it used to be a practice of bears to swim in the open concrete reservoirs so that it was necessary to erect storm-proof barbed wire fences about them.

Why Water Remains Unsterile

Where the water is treated in coagulation, sedimentation, and sand filtration plants. an investigator will meet conditions of every description. Changes in operating personnel may be so rapid as to place the plant under a totally inexperienced man, or the policy of the town may be so strongly for economy as to result in inadequate chemical treatment of the raw water. Many a filtration plant has been seen where various parts were not in operation, due to loss of head gages, rate controllers, etc., and where no accurate measurements were made of quantity of water treated and amount of chemicals added.

Liquid chlorin machines have been found either out of commission or operating unsatisfactorily. Either the operator would not understand the working of the machine, or duplicate parts would not be available, and the machine would be inactive awaiting the part broken; or the amount of water to be treated would not be measured accurately, or the chlorin supply had given out, or the point of application of the chlorin to the water did not permit of adequate treatment. Many times the consumers have complained against the unpleasant chlorin tastes arising from overdosage. As a result, several cities have decreased the chlorin added below the amount necessary for sterilization. Such a case resulted in a typhoid fever outbreak in a Utah city in October, 1924, after the state health officer had warned the city officials for several years.

With respect to chlorination of waters, it is interesting to note the attitude of certain cities known all over the country for their resort features. In North Carolina and Colorado cities, where water from mountain catchment areas is used untreated and the streams on the watersheds are subject to contamination from various sources, the city officials were against chlorination because it would detract from their advertisements that their water was from pure mountain streams. This feature not only outweighed the possibility of a water borne disease outbreak, but also the use of chlorin as an additional factor insuring against such outbreaks.

Frequently, town officials will say that the water is 98 per cent pure, or will use some other high figure. There is no such standard of purity in waters. Upon investigation, it will be found that this statement is based on unreliable bacteriological analyses. In a 1924 Wyoming survey it was found that such a statement was based upon analyses made in 1912.

The collection of samples of water should be deferred until the end of the survey when the whole system is understood and fair sampling points can be determined. The time of collection should be such that the samples will reach the laboratory at the earliest time and at an opportune moment as regards other laboratory work. The method of collection is as given in the latest standard methods of the American Public Health Association.

After conferring with the waterworks officials, it is usually well to see the town health officer in regard to water borne disease statistics and the general quality of the water. In respect to the prevalence and distribution of the diseases, records of cases and of deaths by months for the past five years should be obtained where the data warrant; otherwise for years. Morbidity reports may usually be secured most readily from the local town authorities, often from their printed annual reports or periodical bulletins. The mortality records may be obtained either from state and municipal reports or from their unpublished records. In some cases it will be necessary to refer to the files of original certificates in order to secure the data. Regarding each epidemic, the following data should be obtained: number of cases; cause of epidemic; nature of investigation; and evidence on which diagnosis is based.

Avoid Personalities

It will also be advisable to see former waterworks officials regarding past and

present views of the water supply and lastly the mayor. There are usually two cliques in a town and by interviewing members of each the investigator will obtain a more accurate and complete understanding of the water supply.

It will be found a wise policy to keep from injecting personal views regarding the water system at any time in the survey. At the end it will be well to discuss the whole system with the water commissioner and possibly the mayor or council. In such a discussion all insanitary features of the system should be reviewed impartially; the possibility of contamination stated clearly; the occurrence of water borne disease outbreaks at other places due to similar instanitary features pointed out definitely and technical literature of some cases presented; and the responsibility of the town in providing a safe water emphasized, making use of the Pittsburg, Cal., case. In this respect it has been found particularly effective to present a copy of the March 24, 1923, Weekly Bulletin of the California State Board of Health, which contains in detail the finding of the court holding the city of Pittsburg, Cal., responsible for typhoid fever cases due to impure city water and awarding damages of over $30,000 to nineteen plaintiffs. This pamphlet alone has brought about improvements in water supplies where other methods proved futile. At the same time the investigator may inform the local authorities of the gist of his proposed report on the survey. Frequently, the water commissioner introduces the investigator to the mayor so that the survey findings may be presented to him directly. At times a meeting of the town council may be called to hear the investigator. It will be found that a plain, straightforward presentation in simple language of actual conditions and facts backed by technical data will bear greatest weight with the council. Outside of the conferences with the waterworks commissioner, the mayor, and council, it is good practice not to mention the water supply. If any information about the engineer's trip is to be given to the newspapers, it should be supplied only through the waterworks commissioner, and should be a simple, brief statement of the purpose of the survey. Too much newspaper publicity does more harm than good in sanitary water surveys, in the long run.

Points in Preparing Report

As much of the report as possible should be prepared in the field, and should include the following sections: general information; history of the water supply; the component parts, and a discussion of each; laboratory results; vital statistics; discussion of the findings; recommendations; and acknowledgments. Pertinent maps and illustrations may well be included.

In regard to the follow-up action, the investigator should consider carefully the local situation, the personalities of the local authorities, the gravity of the insanitary features, the economic condition of the community and like information, and then prepare a reasonable follow-up program based upon persuasive and educational methods, the most necessary conditions to be improved first, and the less important later. From time to time letters should be written to the local authorities in regard to progress of improvements. When information is received regarding new water borne disease outbreaks due to supplies with insanitary features similar to those of the town in question, copies should be sent to the local authorities pointing out the relation to the local system. If a neighboring town is making rapid strides toward improving its water supply, it will be of advantage to point this out to the town whose water supply is under investigation.

Where a state department of health is endeavoring to improve insanitary features in a public water supply the cooperation of Federal agencies may be enlisted to good advantage. The United States Forest Service controls the national forests and lets some of the land for grazing purposes. If such grazing affects the purity of a water, arrangements can be made with the Forest Service to limit such grazing sufficiently to protect the supply. Where a supply is used by railroads for drinking and culinary purposes on cars operating in interstate traffic, the railroads and the United States Public Health Service can assist through the certification of such waters in accordance with the Federal interstate quarantine regulations.

Outcome Depends on Investigator

In conclusion, it may be stated that the real outcome of a sanitary water survey depends primarily and essentially on the investigator. According to the new drinking water standards, he should have "a technical education equivalent to that given in a course in sanitary engineering in a college of engineering or school of public health; should have a broad knowledge of the sanitary features and

physical facts concerning water supplies for potable use; and should understand the essential features of water purification plants, their operation and methods of testing." In addition, the investigator should have a pleasing personality and a willingness and ability to ascertain all the necessary data without antagonizing people.

CONCLUSIONS ADOPTED BY INTERNATIONAL ROAD CONGRESS

At the Fifth Annual International Road Congress, held Sept. 6-12, at Milan, Italy, under the auspices of the Permanent International Association of Road Congresses, 50 countries were represented by official delegations, the total number of representatives being well over 1,000. The official delegates from the United States were Thomas H. MacDonald, Chief U. S. Bureau of Public Roads; Paul D. Sargent, Chief Engineer State Highway Commission of Maine; John N. Mackall, Chairman State Roads Commission of Maryland; H. H. Rice, Vice President General Motors Corporation; Geo. Pyke Johnson, National Automobile Chamber of Commerce; H. C. MacLean, Commercial Attache, U. S. Department of Commerce at Rome, and H. H. Kelly, Assistant Trade Commissioner, U. S. Department of Commerce at Paris.

The subjects discussed by the Congress included (1) Concrete Roads, (2) Roads Using Bitumen and Asphalt, (3) Standardization of Tests for Acceptance of Materials for Roads, (4) Census of Traffic, (5) Development and Organization of Towns in the Interest of Traffic and (6) Roads Specially Reserved for Motor Cars. Some 50 or 60 reports on these subjects were presented, giving the practice and experience in many of the leading countries. Some 20 reports were submitted on concrete roads alone, these dealing with the methods and experiences in the United States, Great Britain, France, Denmark, Italy, Belgium, Sweden and the Low Countries. Reports on bituminous and asphalt roads were presented by representatives from the United States, France, Great Britain, Italy, Belgium, Sweden, Switzerland and Holland.

The adoption of the final conclusions on the various subjects enumerated above met with very little opposition except in the case of special highways for motor vehicles. On this subject the delegates from the United States and Great Britain refrained from voting. The final conclusions adopted by the Congress were as follows:

Concrete Roads

(1) The development of cement concrete roads which has taken place with good results, even on routes traversed by heavy vehicles with tires, serves to demonstrate the suitability for traffic of this kind and in great volume, when such roads have been constructed in every respect by the improved methods which have already been adopted by road engineers. For roads over which pass a considerable number of vehicles with metal tires, no satisfactory system has yet been evolved.

(e) The experimental tests with special concretes must be continued, as those so far carried out even under the ordinary conditions of traffic have given no reliable results.

(3) The general proportions laid down at Seville for the composition of concrete having been confirmed, the proportion of cement must in every individual case be specially determined in accordance with the thickness to be adopted for the slab and the quality of the materials available.

(4) The experimental tests in connection with the technical and economic suitability of metal reinforcement in concrete roads, as compared with other forms of construction intended to preserve the concrete work where the foundations are not very firm and are subject to special stresses, must be continued.

(5) Engineers are still very divided in opinion upon the advisability of transverse and longitudinal joints in concrete carriageways. When recourse is had to joints, the intervals between them are extremely variable. Observations should therefore be continued.

(6) As to the jointing material to be adopted when joints are provided, experiments should be pursued in order to ascertain the best type, with the object of simplifying as much as possible the mode of preparation and the method of application.

(7) The practice of constructing roads with alternating slabs, for the purpose of reducing the dimensions of expansion joints and of diminishing cracks, deserves attention and should be further investigated.

(8) The coating of concrete roads with

hydro-carbano or bituminous mixtures may, in many cases, be productive of notable advantages, and should be further investigated and carefully examined.

(9) The experimental tests in connection with the silicatization of the surfaces of concrete roads with a view to their being made harder and to secure better preservation must be continued.

(10) The use of mechanical processes for the construction of concrete roads is advisable from the technical point of view, whenever economic difficulties or special working conditions are not encountered.

(11) For repairing damaged parts of such roads, the use of mechanical appliances is to be favored, quickly hardening cements or asphalt concretes being employed for repairs according to local possibilities and seasonal conditions.

Bituminous and Asphaltic Roads

Natural Rock Asphalt.—(a) The asphaltic rock must be homogeneous and free from any foreign substance, entirely impregnated with bitumen, and must not contain clay in any appreciable quantity. It is recommended that the maximum limit be 2 per cent estimated in oxide of alumina.

(b) The percentage of bitumen, which may vary between wide limits from 6 per cent to 13 per cent obtained; if necessary, by blending appropriate proportions of natural asphalt rock or by the addition of hydro-carbons, must be controlled according to the climate and traffic, remaining within the lower limit in very hot climates and with very heavy traffic, and within the higher limit in the reverse case.

Non-asphaltic Mineral Materials.—(a) Mineral materials, not naturally asphaltic, and used in bituminous roads, are classified as follows:

Course aggregate—retained by a screen ¼, or 6 mm., square mesh.

Fine aggregate—passing through the above screen and retained by a Standard No. 200 screen, or with 6.200 meshes per square centimeter. Filler—passing through the above No. 200 screen.

(b) In the layer exposed to traffic of any type of bituminous road, use should be made as course aggregate of a stone or gravel, or a mixture of these materials, obtained from hard and tough rock, preferably of volcanic origin or limestone. Some clinkers are also used with good results.

(c) In the lower layer of double-coat roads, use may also be made of second class or scrap materials, but increasing the quantity of bitumen in the mixture accordingly. In each particular case, the choice of the coarse aggregate must be made with a view to economy, by endeavoring to utilize the less costly among the sufficiently good materials.

(d) The maximum size of the coarse aggregate depends on the type of road, the method of execution, the nature of the traffic, the quality of the foundation. For roads of the macadam type with penetration and for the lower layer of double-coat roads, the limit to be adopted, according to the present practice, should be the dimension of 2½ in., or 65 mm., except in special cases. For the wearing surface of double-coat roads and for single-layer roads made on the mixture principles, the maximum dimension should be 1½ in., or 40 mm.

But in some very common types, 25 mm. are not exceeded. It is recommended, in any case, that the size of the material should not exceed half the thickness of the road layer concerned. It is further recommended that as traffic increases the maximum dimensions of the fragments of stone be proportionately reduced.

(e) As a rule, the coarse aggregate is required to be supplied in several sizes, two at least, and that the various sizes be proportioned so as to obtain a whole of a maximum density, that is to say, so as to reduce to a minimum voids to be filled with the bituminous paste. In some roads mostly formed of a compact asphaltic paste, the coarse aggregate may also represent a small portion of the mass and have the sole purpose of rendering the mass itself less plastic and running; in such cases, the sizes of the coarse aggregates are usually very limited—from ¼ to ¾ in.—and it is then preferred that the size of the material be uniform.

(f) Fine aggregate may consist of sand of any description, provided it is sound and free from any impurities; also of fine chippings from the crushing of rock and certain clinkers. For fine aggregate, a correct graduation is specified between certain limits regarding the percentage which must remain between two successive screens of the standard series, the object being to give a maximum compactness to the bituminous paste.

Should any given material lack any of the elements required to obtain the correct graduation desired, this must be ad-

justed by mixing another suitable material with it.

(g) For filler, it is advisable to use ordinany Portland cement, or finely powdered hydraulic lime, or again, a fine powder recovered from the grinding of a suitable stone. It is advisable that the material used as filler should not leave more than 20 per cent of residue on a Standard No. 200 screen. It is recommended not to rely for a filler on the portion of a fine aggregate which passes through the Standard No. 200, as this "fine material" should rather be considered as impurities in the "fine aggregate."

Bituminous Binding Material.—(a) The tests at present in use for bituminous materials are sufficient on the whole, to ascertain whether a given bitumen is suitable for a given road under given conditions. The Congress, however, expresses the desire that a practical method may also be found of measuring the dimension of a bituminous binding material to an aggregate, and that a complete study should be made of the action of the very fine mineral matter incorporated in bituminous binders, on the so-called asphaltic characteristics of the binding material itself.

(b) The penetration figure, usually determined at 77° Fahr. or 25° C., though it may be taken as sufficient to ascertain the constancy to type of a bituminous binding material, provided that the origin and method of preparation are also constant, is not sufficient to give the suitability of such a material to the requirements of a given use. It is recommended to add to specifications for bituminous binding materials, the softening or melting point, obtained for preference by the ball and ring method.

(c) The ductility test, carried out at the one temperature of 25° C., in certain cases is of little significance. It is recommended to add to the specifications a low temperature test—say, at zero—and also a test at a higher temperature when dealing with bitumen which at a temperature of 25° C. give an elongation not exceeding 50 centimeters.

(d) For asphaltic binding materials it is recommended that the asphalteness be determined by solution in naphtha, naphthalene or petroleum ether. When standardizing the methods of testing bituminous materials, it will also be necessary to define the characteristics of this solvent, to specify its nature, its density and the limits of distillation.

(e) The penetration figures, suitable for the various bituminous roads, very considerably according to the method of execution, the climate, and also the quality and intensity of traffic to which they are subjected. The degree of penetration must decrease in proportion with greater compactness in the mixture, greater fineness of aggregate, greater heat and dryness of climate, and greater intensity of traffic.

It is impossible to state—a priori—the figures corresponding to each combination of these variable factors. The particular cases, however, mentioned in the reports to the Congress, may well serve as a guide for a rough approximation, the assistance of local experience being necessary in any case.

In several countries good results have been obtained by preceding the surface bitumen treatment by a preliminary surface dressing with tar. This method is especially recommended for macadam surfaces composed of friable and dusty materials. Further in the experience of several countries, the mixing of bitumen with a percentage of suitably prepared tar facilities bituminous coating.

It appears that the addition of tar to an asphaltic binding material, when making asphalt concrete, makes it possible to apply the mixture at a lower temperature. There is therefore good reason for a close study of these mixtures of bituminous binders with tar and its derivatives, either for improving the conditions under which use is made of the materials themselves, or for the sake of economy, wherever the cost of tar and derivatives is considerably lower than that of bitumen.

Standard Tests for Materials.—The Congress is of the opinion that a committee to meet in Paris (headquarters of the Permanent International Association of Road Congress) should be appointed by the Congress for the purpose of:

(a) Settling a nomenclature for the principal materials and methods employed in connection with road construction.

(b) Standardizing the methods employed in taking samples and in testing the materials in question.

The Congress asks the Presidential Commission of the Congress to appoint this committee in consultation with the Central Bureau of the Permanent International Association of Road Congresses with the reservation:

(a) That the committee should represent the languages admitted at the Con-

gress as well as Spanish and one of the Scandinavian languages.

(b) That the committee should nominate with representatives of other languages according to the nature of the subject.

(c) That in every case there should preferably be appointed to the Commission representatives of the various national associations already appointed for this purpose in the different countries concerned.

Traffic Census

(1) The result of the census will be set out with reference to each section covered by an observation post.

(2) For each section an indication will be given of the daily average deduced from all the days of observations, which must be speciffically indicated, as well as the month or months in which the observations have been taken, and the daily duration. These averages will be reduced to the twenty-four hours by suitable additions for night traffic.

(3) For each section an indication will also be given of the yearly averages for the traffic units in each class separately, taking into account the period of census and of possible variations for other reasons established through special experience and observation. This will make it possible to know the number of vehicles of each group passing in one year on the section under consideration.

(4) Whatever may be the classification of individual vehicles in the various countries and on the various roads for special purposes and in connection with special local conditions, the users of the road should be grouped into the following classes: (a) Animal traction vehicles; (b) mechanically propelled commercial vehicles and motor omnibuses with pneumatic tires; (c) mechanically-propelled passenger-carrying vehicles with pneumatic tires (i. e., motor cars not including motorcycles); (d) mechanically-propelled vehicles with solid tires; (e) motorcycles; (f) bicycles; (g) pedestrians; (h) animals unharnessed or ridden; (i) hand cart, etc.

The last four groups are accessory, and will only be counted if it is considered necessary.

(5) The results of the statistics will be indicated, and also the following data which may vary from country to country, and from road to road: (a) Average gross weight attributed to vehicles of each group, bearing in mind the variable proportion between heavy and light vehicles, the probable number of vehicles empty or partially loaded and, for animal-drawn vehicles the proportion between those with one or several draft animals. (b) Average width of the section of road under consideration, taking into account the modifications necessary owing to the presence of tramway lines. (c) Length of the same section. (d) Nature of the road surface and the state of repair. (e) The weather at the time of the census. (f) As an addition and accessory, the average useful weight carried by the vehicles unit of each group, as regards good vehicles only.

(6) It would be desirable that each nation, in connection with its census, in order to make the results comparable, should give for each section on which the census is taken—(a) The average daily numbers registered under each group of users of the road. (b) The average gross daily tonnage.

(7) An international committee should be appointed by the Congress to consider the standardization of census returns, in the light of the present conclusions.

The Development and Planning of Towns in the Interests of Traffic

(1) An exact and correlated study of the building regulations for cities and of schemes for their planning and extension is one of the fundamental conditions for satisfactory street traffic, and what is even more important, for the general welfare of the community. This study should be co-ordinated also with the street regulations of the police, both those in force and those it is proposed to adopt. Above all, therefore:

(a) Every modification in the building regulations should be associated with a modification in the fundamental plans, which takes into account the effect on street traffic of the altered building conditions.

(b) No scheme for the modification of the street system can ignore the police regulations for the control of the traffic, though the aim should be to reduce these regulations to a minimum.

(c) An accurate and statistical statement as to the traffic conditions should serve as a guide in any scheme of town planning; a consideration of the building regulations proposed for various districts in an extension scheme, and an examination of their relation to each other is essential in the planning of the street network scheme.

The extension scheme must cover a sufficient area to include the points of origin of the streams of traffic; it must not be elaborated in ever detail, but must

be regarded as a skeleton plan of the principal lines of traffic. It is also essential to take into account considerations connected with traffic control, the configuration of the town in question, and the uses to which the buildings and streets are to be put.

(d) The plan must control the use of the land in the various quarters, fixing in relation to this use the building lines, and the widths of the streets, the height of the buildings and their distribution.

(2) It may be difficult for economic, historic or artistic reasons, to introduce into the central nucleus of a city such an orderly layout as is required by modern needs. Recourse must therefore be had to partial expedients to lessen the inconveniences inherent in a network of streets conditioned by the density of the buildings and of present-day traffic. Such expedients may take the form of:

(a) Local improvement in the street network.

(b) Improved traffic control in the streets as they are.

(c) The diversion of traffic from the central nucleus.

(d) The decentralization of offices and industries which may, with advantage, be transferred to the outskirts of the city.

(3) Any amendment made in the street system within the central part of the town should not be a merely local scheme, but should form part of a general scheme to systematize the central nucleus itself, and also to take account of the requirements of traffic as a whole and of communication between the several districts.

(4) The difficulties in the way of any widening of the street sites in the centers of the cities to make them adequate to the volume of traffic, render it necessary to raise the efficiency of the existing streets. The following methods, most of which had already been indicated at the Congress of Seville, have proved effective in practice.

(a) The exclusion from streets intended for dense traffic of whatever is not strictly necessary, either in the form of stationary or moving objects, and above all to avoid:

(I) The locating of shrines, sentry-boxes, kiosks, market-booths, coffee-stalls, advertisement-hoardings, etc.

(II) The parking of vehicles.

(III) The transit of slow and cumbrous vehicles.

(b) As a counterpart of these prohibitions, it is necessary that any plan for the layout of the central part should provide facilities.

(I) For the widening of streets where urgently necessary.

(II) For the making of spaces or buildings for the parking of vehicles and above all for the reception of automobiles.

(III) For constructing or organizing lateral arteries alternative to the main traffic thoroughfares, through which the slow and heavy vehicle traffic may pass.

(c) The removal of anything tending to create an interruption in the steady passage of the vehicles and more particularly: by means of overhead ways or combined signals; by the adoption of one-way traffic where necessary; the avoidance of too long and too frequent stoppages at the crossings in the leading thoroughfares; by scrupulous supervision on the part of the street police; by preventing the normal flow from break interrupted by the turning of individual vehicles so as to break into the stream of traffic.

(5) The construction of elevated and underground streets has not yet been carried far enough to warrant the inference that they will provide effectual relief for the traffic.

It may be remarked, however:

(a) That the utilization of the subsoil for the purpose of relieving the street-level traffic should form part of a general plan embracing the co-ordination of the urban underground railways, with the provision of auto garages, subways, and possibly also underground tramway stations.

(b) That pedestrians avoid using the subways mainly because these are approached by stairs which seem to constitute a barrier to traffic. It is recommended that where possible gently-sloping ramps be provided as approaches to the subways, and that the subways themselves may provide some attraction from shops, etc., located in their sides.

(c) The same principles should apply to the construction of overhead ways.

(6) The suppression of tram lines in the heart of the city should be carried out step by step as facilities arise from the development of other and less cumbrous means of public transport and, above all, from the construction of underground lines in localities where they do not now exist. In cases where such lines are already in existence, it should not be forgotten that their capacity is not unlimited and that the suppression of he tram lines can only take place if the

underground lines can carry a heavier volume of traffic. In order to prevent inceasing congestion it is desirable that all forms of public passenger transport should be co-ordinated and should be under the control of the same administration.

(7) The diversion of traffic from the heart of a town should be effected:

(a) On the basis of a comparative study of the plans for extending the town, and for systemizing the layout of its center. Every extension of the town should be designed not merely by itself, but also with regard to its effects on the lines of communication with the center, with the other districts of the city, and with its suburbs.

(b) By the distribution of the traffic, which should be done by the making of wide arteries to divert it by the quickest route from the thoroughfares which convey the traffic into the city to its various quarters of destination. The construction of concentric ring roads to knit up the radial thoroughfares has proven to be less advantageous the larger the diameter of the circle becomes

(8) The displacement of large administrative services to the outskirts is advisable in the interests of the street traffic when such service can be divided up into departments each enjoying a large measure of autonomy. Otherwise the displacement may result in an increase of traffic.

(9) It is preferable that the public transport services should carry the passenger traffic to points near to the center, while avoiding the spots already overburdened with traffic.

(10) The distribution of areas according to the type and use of building (zoning) may promote a good circulation of the traffic if the distribution of the several quarters has been systematically planned. In this connection it is necessary to remember that widely-spaced buildings of large size may be responsible for a large increase in the number of vehicles, and thus congest the traffic in business quarters.

(11) Keeping always in view the reservation of the streets for moving traffic, it is necessary, in the distribution of the quarters, to keep in mind the necessity for maintaining areas reserved for parking vehicles, and for parks and gardens for children's amusement .

(12) The planning of the street network in new districts should take account of the traffic requirements and give primary consideration to the following factors:

(a) The construction of a ground network fixing the traffic axes.

(b) The determination of the streets that are to distribute the traffic.

(c) The exact designing of the interconnections of the streets with each other and more particularly of their inlets and outlets.

(13) The main thoroughfares should allow of the laying out of separate tracks, specially adapted to different forms of traffic. They should be capable of being widened so as to meet future requirements. Steps should be taken to provide facilities for pedestrians to cross these arteries of traffic.

(14) The principal arteries of urban traffic must be co-ordinated with the arteries of traffic in the surrounding areas. From this point of view it is desirable that the schemes should take into consideration whole regions and co-ordinate their lines of traffic.

(15) It is desirable that street control and street signalling should form a coordinated whole. More particularly, the street signals should be conveyed not only in printed character; the form and color of the signal should make its meaning understood at a glance without the necessity of reading the inscription.

(16) Systematic control of traffic has been steadily extended. It is desirable that this control should assume everywhere common characteristics. This would call for the fullest collaboration between the associations of road users and the public authorities.

The Congress expresses the hope that steps will be taken as soon as possible to call a diplomatic international conference, with a view to securing uniformity of traffic signals in urban areas by means of signs which can be easily understood without the necessity of reading an inscription.

Special Motor Roads

Conditions Justifying the Creation of Motor Roads.—(a) The creation of roads reserved for the use of motor traffic may be considered as justified when the mixed traffic on the ordinary highways in the neighborhood of, or between, densely populated centers, or passing through places which have a busy industrial, commercial or pleasure traffic leads to a saturation and a deadlock dangerous to the circulation and contrary to transport economy. Also when the absolute preponderance of motor traffic of every kind (passenger, goods, fast and slow units) render it necessary to ensure for it the highest possible return in the

form of speed, non-stop running and safety.

(b) When estimating the foregoing conditions, extreme prudence must be observed, and one must not let oneself be carried away by a spirit of easy optimism. On the one hand must be weighed the benefits obtained from economy in transport (time, wear and tear, staff), and the savings effected by not carrying out the difficult and too costly improvements to existing roads which with careful maintenance or with only slight improvements might still be made to serve, as against the outlay required for the construction, upkeep and running a motor road. Other elements, too, and not to be valued in figures, must be borne in mind, such as safety to life and limb, general advantages to the towns and districts directly interested under existing conditions, and in the light of probable developments.

(c) As, generally speaking, the motor road cannot replace existing highways, neither can it pretend to exclude motor vehicles from them, even over the same distances.

Execution and Control of Works.—(a) The construction and running of a motor road, even when not aided by public bodies, must always be the subject of concessions on the part of public authorities.

(b) Even when the line of motor roads does not materially pass beyond the boundaries of a province, township or borough, etc., the concessionary powers must always be reserved to the State, which is the supreme guardian of public interests and supreme regulator of the juridicial and economic relations between public and private persons.

(c) The control of the construction and use of a motor road as a consequence of the concession will always be in the hands of the State, and in particular, will be subject to the direct control of one of the executive departments.

(d) The concession should be limited in duration, and it would be desirable to provide for a power of purchase by the State at any time during the duration of the concession.

Finances: Contributions by Public Bodies: Tolls.—(a) On these points it is not possible to draw up general and absolute rules. Where the use of motors is widespread, it may not matter much whether the motor road is financed out of the nation's general balance or from a general motor tax. Where there are but few cars on the roads it would be unjust that all the citizens or even the car owners alone should be called upon to pay for the motor road. In this case instead, it is quite fair and natural that a special tax should be levied upon those who willingly make use of a speedier and more convenient means of transport over certain distances, while they are still free as any other motorist to choose between the motor road and the ordinary road.

(b) This system of special taxation by which the motor road pays for itself means to say that there would be no motor road undertakings where, after due inquiry as to the possibilities of the traffic, a sufficient income deriving from taxes and other charges could not be relied upon. Nevertheless, the regime of a special tax does not exclude subventions by public bodies in consideration of general public interest, which cannot be precisely valued. The subventions may be of different form and varying degree. For instance, they may assume the form of donations, repayable loans, guaranteed interest on capital or only part capital.

(c) The tariffs for the use of the motor road must, in the interest of the public, be approved by the public authority if only in order to guarantee equality of treatment to all. They must be such as not to exceed the economic advantages of motor road transport over ordinary road transport, they should not be unduly complicated, and should be so sectionized that they do not hinder the utilization of the motor road by intermediary centres and the districts passed through.

Rules for Operation.—(a) Since it treats of a public service even if of private initiative, the rules and by-laws must be approved by the State.

(b) Motor roads must be absolutely independent and separate from all other roads and from all property without their bounds. They must, therefore, be rigorously fenced off throughout their entire length. They must have gates at their extremities and on all roads giving access to them and there must also be gatekeepers. This rule is quite independent of whether tolls are demandable or not.

(c) The ordinary regulations for the control of traffic should be enforced, and also rules similar to those in force on railways to prevent entry and trespass.

It may be anticipated that on motor roads higher limits of speed will be permitted than those in force on the ordinary roads. But drivers will have greater

responsibilities and there will be severe penalties for those who allow cars to get out of control, who fail to heed the traffic by-laws, signals and orders.

(d) So long as heavy motor lorry traffic does not become exceptionally intense and provided that the motor road is sufficietnly wide to allow of vehicles to pass one another while still keeping to their right side it is neither opportune nor necessary to divide the traffic into light and heavy and run them on different tracks.

(e) Vehicles may turn back without being obliged to go out and re-enter, provided that they do so where there are keepers who can take the necessary precautions and set the signals.

(f) Stops, save in response to signals or orders, must only be made near the banks running alonside or at the special stopping places.

(a) Level crossings, either road or rail, must be excluded absolutely. The continuity of the motor roads must be ensured by means of tunnel bridge. Nevertheless, the public secondary and private roads can be indirectly linked up by making them open out, singly or in groups, on to the chief ways so as to take advantage of the bridges and tunnels attached to them. The competent authorities when approving the scheme will be careful to see that the local interests and road systems of the districts to be traversed are affected as little as possible.

(b) The motor road junction roads connecting up with neighboring centers and existing highways must be chosen and laid with due regard for the importance of the district to be traversed; must be sufficiently wide and to allow for perfect visibility where they open on to the motor road; must be furnished with signals at suitable distances on both sides and be supplied with a toll bar and a toll keeper.

(c) Theoretically, it is desirable for vehicles entering and leaving by means of the junction roads not to cross the track reserved for the opposite direction to their own. But these crossings may be effected without inconvenience or danger by the observance of the rigorous discipline for the control of traffic which is essential to the motor road. Consequently, except in cases of extreme difficulty and traffic congestion, one can do without costly and complicated methods, such as junction branches and circuits provided with bridges and tunnels, which otherwise would be necessary in order to eliminate them entirely.

SUGGESTED PRACTICE CODE FOR ENGINEERS

Editor's Note: The following code of profession practice for engineers is a tentative draft based on a compilation prepared by the Northeastern Section of the American Society of Civil Engineers as printed in the Proceedings of the Society for September, 1926.)

The Tentative Draft of a Code of Practice, which in its original form was prepared by a Committee of the Northeasters Section, was presented to the Board of Direction by the Committee on Professional Conduct, with a few minor changes and additions.

The Board ordered this amended draft publishedin Proceedings, with the request for comment from the membership, looking toward further improvement. Comments on this draft by the membership are, therefore, requested.

It was felt that the adoption of such rules and regulations as are contained in the draft appear desirable but that their adoption should be held under advisement until all parts of the country have had opportunity to discuss them.

Introduction

Many Codes of Ethics and Codes of Practice have been examined and eleven have received close study. The purpose has been to retain the best features of these existing codes so far as they apply to Engineers.

This Code is prepared with the hope that it may prove of value to those engaged in construction, without interfering with other codes prepared for specific purposes.

The eleven codes mentioned are those of the following organizations:

Texas Section, American Society of Civil Engineers,
American Society of Civil Engineers,
Boston Society of Civil Engineers,
American Institute of Consulting Engineers,
American Institute of Architects,
New York Building Congress,
Boston Building Congress,
Associated General Constractors,
Milwaukee Chapter, Associated General Contractors,
Industrial Association of San Francisco,
Master Builders Association of Boston.

Preamble

Any Code of Ethics is founded on the Golden Rule. A Code of Practice is an application of the Code of Ethics.

This is a Code of Practice. It is intended as a statement of conduct which

is right under most circumstances. Examination of and experience with practically every article in it will reveal that there are special circumstances when that article ought not to be applied rigidly, if applied at all. It is therefore not intended as a code of laws, but is intended for a set of statements so generally true that there is a burden upon the Engineers to observe them, except when he shall satisfy himself that in his particular case the statement made does not apply.

Its purpose is not so much to impose on any one the judgment of others as to set each one thinking and forming his own judgment. Every member of a profession is, or should be, constantly revising and enlarging his conception of the conduct proper to that profession, and to this essential process of becoming his own judge, a code of practice is a great aid. It calls attention to practical applications of the Code of Ethics which might not be in the minds of some members, especially those of less experience.

Contents

I.—The Relations of Engineers Among Themselves.
II.—The Relations of the Engineer with the Owner.
III.—Relations Concerning Contractors.
IV.—Relations Concerning Sub-Contractors and Material Men.
V.—Relations with the Public.

For "Engineer" as herein used, "Architect" may be substituted when conditions require it.

Part I.—The Relations of Engineers Among Themselves

Every Engineer shall satisfy himself, to the best of his ability, that the enterprises with which he becomes identified are of legitimate character. If, after becoming associated with an enterprise in good faith, he finds it to be of questionable character, he shall sever his connection with it as soon as practicable.

2.—No one shall falsely or maliciously injure, directly or indirectly, the reputation, prospects, or business of another. The repetition of rumors, not positively known to be true, is but one degree less reprehensible than the making of a statement known to be false. This shall not, however, prevent protest against unethical practices on the part of others. Such a protest shall be submitted, together with the facts in the case, to the governing body of the organization of which the offender is a member, to be handled as provided by said organization's Constitution and By-Laws.

3.—Credit for work and ideas shall be attributed only to those who are the real authors.

4.—Services of an Engineer in the employ of some one else should not be secured without first communicating with his employer.

5.—An Engineer should not accept employment with another employer without first consulting his superior.

6.—A superior should not stand in the way of advancement of a subordinate.

7.—Publicity of the standards, aims, and progress of the profession, both in general and as exemplified by individual achievement, is essential. However, self-laudatory individual publicity procured by, or with, the consent of the person advertised, is unethical in that it tends to lower the dignity of the profession.

8.—It is improper for an Engineer:

(a) To accept employment while the just claim for compensation or damages, or both, of a fellow Engineer previously employed on the same project and whose employment has been terminated, remains unsatisfied, or until such claim has been referred to arbitration, or issue has been joined at law, or unless the Engineer previously employed has neglected to press his claim legally after reasonable period of time.

(b) To attempt to supplant a fellow Engineer after definite steps have been taken toward his employment.

(c) To participate in competitive bidding against his colleagues for engineering work which is to go to the lowest bidder, nor to attempt to secure work by reducing his ordinary charges for professional services after being informed of the charges named by a competitor.

(d) To offer commissions or to otherwise improperly solicit professional work either directly or indirectly, or to engage in the practice of making preliminary studies and estimates of cost for proposed projects and of giving other professional service or advice without adequate compensation.

(e) To accept any engagement to review that work of a fellow Engineer, except with his knowledge.

9.—When an Engineer is engaged to make alterations of, or additions to, any construction designed by another, he shall bear in mind the original conception of the author. When practical then new design shall be submitted to the original designer as a professional courtesy.

10.—Participation by engineers in competitions for the adoption of plans according to merit, or where prizes are

offered, is always undesirable, and should be considered permissible only when the decision as to merit rests with persons technically educated and competent to pass judgment thereon.

Part II.—The Relating of the Engineer with the Owner.

1.—The Engineer may act as designer, supervisor of construction, or professional adviser to the Owner. He shall act in a strictly judicial manner.

2.—The Civil Engineer should always charge for professional advice, regulating his charges according to the interests involved, whether his client be a private citizen, a corporation or a municipality.

3.—Except with the consent of the owner, he shall not accept any other renumeration than his direct charges for services rendered the Owner.

4.—Unless and until authorized by the Owner, he shall not receive, directly or indirectly, any royalty, gratuity, or commission on any patented or protected article or process used in work upon which he is retained by the Owner.

5.—He shall not accept any trade commissions, discounts, allowances, or any indirect profit or consideration in connection with any work which he is engaged to design or to superintend, or in connection with any professional business which may be entrusted to him.

6.—He shall not directly or indirectly engage in any of the building trades.

7.—He shall inform the Owner of any business connections, interests, or circumstances which might influence his judgment of the quality of his services.

8.—Consultation with Engineers who have made certain branches of professional work a specialty, or who have acquired a pre-eminent standing in the profession, may be requested by the Engineer having general charge of any work or may be required by the Owner thereof. In either case the employment of the Consulting Engineer must be satisfactory to both Onwer and Engineer and shall be at the expense of the Owner. Such employment should be encouraged.

No Engineer should agree to act as Consulting Engineer except at the request or with the consent of the Engineer in direct charge of the work; and his reports and advice should be confined to the particular matters with reference to which he has been consulted.

Charges for consultation should be based on the value of the services rendered rather than on time required in arriving at conclusions or opinions.

9.—The Engineer when acting as supervisor is the official interpreter of the contract and must insist upon its faithful performance by both parties.

10.—Planning, designing, and supervision are the functions of the Engineer. All such problems should be presented by the Owner to the Engineer rather than to the Contractor.

11.—As a complete engineering or architectural service, the Engineer shall furnish promptly whatever general, structural, and mechanical plans, details, and specifications as are needed for bidders or contractors. He shall not require bidders, contractors, or subcontractors to make any part of such drawings or specifications without payment.

12.—He shall not attempt to conceal possible oversight or errors, nor attempt to shirk responsibility by indefinite clauses in the contract or specifications. The specifications shall clearly define unusual trade terms or trade names and customs understood to be part of the specifications.

13.—The Engineer shall see that the Owner decides before plans or specifications are detailed, whether he will let a general, segregated, lump-sum, cost plus fee, unit price, or other form of contract.

14.—The Engineer is entrusted with financial undertakings in which his honesty of purpose must be above suspicion; he acts as professional adviser to the Owner and his advice must be absolutely disinterested; he is charged with the exercise of judicial functions as between the Owner and Contractor and must act with entire impartiality; he has moral responsibilities to his professional associates and subordinates; finally, he is engaged in a profession which carries with it grave responsibility to the public.

Part III.—Relations Concerning Contractors

1.—A contract that is fair to all parties is a sound basis for amicable and pleasant relations between the Owner, the Engineer, and the Contractor. Several contract forms have been prepared by committees of various technical societies. These forms are recommended for study and reference so that contracts of similar types may as time goes on approach common standards. The Engineer should incorporate in his contracts any provision which he considers necessary to protect the interests of either Owner, Engineer, or Contractor.

2.—The general, rather than the segregated, contract for both public and private construction work is as a rule more satisfactory and economical for the

Owner, the Engineer, and the Contractor. When segregated contracts are used for the several parts of a single project much of the Contractor's responsibility is placed upon the Owner.

3.—The Engineer shall see that full information and facilities, such as access to site, completed plans, adequate time and quantity surveys where practicable, are offered to all those estimating. This procedure is for the ultimate benefit of the Owner, as well as the Contractor.

4.—The following provisions regarding the letting of contracts have been found to be good practice:

(a) The preparation of an intelligent bid involves time, labor, and expense. The rules of fairness and honor shall govern its use. The contract shall be awarded on the basis of the original bid, except when substantial change is made in the work, or when further bidding on alternate items is requested. Any reduction of a bid disproportionate to such change constitutes unfair competition.

(b) A bid received from a Contractor or Material Man, whether in open competition or privately, should not be used as a lever to secure lower prices from competitors; nor shall all competitive bids be rejected for the main purpose of using the information derived from them as a means of securing lower bids from those who competed or from others. After the acceptance of the bid, any changes which would have materially changed the bidding shall be avoided whenever practicable.

(c) When bids are solicited and received by an Owner on a lump-sum basis, no competitor other than the low bidder shall solicit the work on a percentage, or any other form of cost plus contract; provided, however, that any competitor shall have the right to accept the work on a percentage basis if tendered him without guaranteed maximum cost or at a guaranteed maximum cost not less than his original bid.

(d) When bids are received on a unit-price basis the whole work covered by the bid shall be awarded to one Contractor.

5.—Engineers shall not call for unnecessary or full estimates from prospective bidders on tentative projects.

6.—The Contractor's professional knowledge is the result of his training and experience and if the Engineer calls upon him for preliminary estimates or appraisals, he should see that he is paid for such service.

7.—Engineers shall eliminate as far as possible alternate estimates, secondary estimates, and allowances when asking for bids.

8.—Where time is important the Engineer shall state a definite date of completion of the work on which all bids shall be based.

9.—The Engineer shall, where possible, endeavor to so arrange that bids will be received only from Contractors to whom he would be willing to award the work. On private work he should invite a limited number of contractors (six is suggested) of satisfactory ability and standing to compete.

10.—It is the best practice to fix a definite time and place for the opening and reading of all bids for a given contract, whether on public or private work, at which all bidders or their representatives shall be permitted to be present.

11.—Where the Engineer is charged with the supervision of work and the issuance of orders for changes, all business shall be transacted through the Engineer.

12.—The Engineer employed to supervise work shall act either personally or through a representative competent for the class of work under his supervision and fully authorized to act for him.

13.—The Engineer should understand that the functions of the Contractor are to furnish the co-ordinating control of a centralized management, often to guarantee to the Owner the limit of cost and the time of completion of the project; also to assume all the risks and responsibilities of physical and business conditions relating to the site, materials, and labor used on his contract except it is not his duty to assume responsibility for conditions at variance with or which cannot be reasonably inferred from plans and specifications.

14.—The Contractor shall be responsible for the details as to method and conduct of the work, subject to the approval of the Engineer. The Engineer shall give as much latitude as is feasible for the Contractor to adopt his own methods.

15.—The Engineer shall insist on a mutual exchange between the Owner and the Contractor of information regarding integrity and responsibility.

16.—The Engineer shall give immediate consideration to, and prompt action upon, the Contractor's applications for payment. He shall not be a party to any desire on the part of either party to anticipate or to delay payments, due under the contract

Part IV.—Relations Concerning Sub-Contractors and Material Men

1.—The principles of Part III, in so

far as applicable, shall govern the relation of Engineers with Sub-Contractors. Material Men are considered as Sub-Contractors.

2.—It is undesirable for Sub-Contractors to supply bids to the Contractor through the Engineer.

3.—No sub-contracts shall be awarded by the Contractor without the consent of the Owner or his representative.

4.—The Engineer shall recognize the following as good practice:

(a) The Contractor shall use bids for labor and materials only from Sub-Contractors to whom he is willing to award the work.

(b) All Sub-Contractors shall be given the same basis for bidding.

(c) A bid received from a Sub-Contractor shall be both final and confidential to both parties.

(d) If in making up his own bid a Contractor has used the bid of a Sub-Contractor, he shall be awarding the sub-contract give that bid first consideration.

(e) In all ways the Contractor shall accord to Sub-Contractors the same treatment he desires for himself. In particular, he shall not withhold payment to Sub-Contractors for work or for materials for which he has received payment. In case of departures from plans and in case of extra work the Contractor shall afford the Sub-Contractor as complete protection as though the work had been done by the Contractor himself.

Part V.—Relations with the Public

1.—National and local prosperity and development affect the employment of the Engineer and the Contractor. Public duty, as well as personal interest, justify the Engineer and the Contractor in advancing worthy public enterprises.

2.—The Engineer and the Contractor shall maintain a dignified interest in the welfare of the community, and should join and support the local civic and commercial associations to the end that the influence of their professions may be felt in all public matters in which their special training, knowledge, and experience qualify them to advise.

3.—They shall endeavor to assist the public in arriving at a fair and correct general understanding of the technical phases of public questions. They shall discourage and challenge untrue, unfair, and exaggerated statements on technical subjects, especially when such statements may lead to, or are made for the purpose of promoting unworthy or uneconomic public enterprises.

4.—They shall accept personally their responsibility as good citizens; assume their proper share of gratuitous public work for the general good; support public officials in the proper enforcement of technical regulations; and take an active interest in the formation and improvement of such regulations.

5.—They shall give consideration to the affect upon the community of every proposed project with which they are connected.

6.—In his attitude toward public technical questions, the Engineer shall bear in mind his responsibility both to his profession and to the public.

7.—Public appreciation of their profession will be increased by the advancement of the technical sciences. They shall promote such advancement by their own efforts and by their encouragement of sound technical training.

8.—In addition to the safeguards required of them, they shall recognize their broader obligation to provide amply for the safety, health, and comfort of the public in so far as affected by their operations.

TO WHAT EXTENT SHOULD BUSINESS AREAS BE LIMITED?

By George H. Coffin, Jr., President, Los Angeles Realty Board, Los Angeles, Calif.

(Paper read before City Planning Conference at Los Angeles, May 1, 1926.)

I submit for your consideration a brief treatise on the subject of business areas, the substance of which was recently adopted by the Planning Committee of the Los Angeles Realty Board as part of their program of study and activity during the year 1926. I trust that certain of the conclusions which I have reached may furnish material for constructive thought for others whose interest is as sincere as my own in the vast subject of city planning.

In the year 1921 in the great northwest section of Los Angeles, there were 26,810 vacant lots, which represented 61 per cent of the area; the use then made of the remaining 39 per cent, or occupied area, was found to be as follows:

Thirty-three per cent devoted to private homes; 3 per cent devoted to multiple family structures, apartments, bungalow courts, flats and hotels; 1 per cent devoted to business purposes, and 2 per cent to industrial usage, being principally the motion picture studios.

Five Year's Survey

Five years later a similar check was made in the same territory and it was found that where 61 per cent was unoc-

cupied in 1921, that only 32 per cent remained vacant in the early part of 1926. The area occupied by single family homes had increased from 33 per cent to 47 per cent, an increase of 14 per cent. The area occupied by multiple family structures had increased from 3 per cent to 14 per cent, a net gain of 11 per cent. The area occupied by business had increased from 1 per cent to 5 per cent, an increase of 4 per cent, and that occupied by industry had remained stationary at 2 per cent.

Grouping all residential usage together, we now find 61 per cent of the area occupied residentially compared with but 7 per cent in use for all business purposes. The above figures graphically illustrate the remarkable development of northwest Los Angeles. There were 12,520 new buildings erected in the five-year interval in that one section of our city. It is but natural to assume that with the 32 per cent vacant area in the territory ultimately fully utilized, that if business is permitted upon 7 per cent of the vacant area, the existing percentage applicable to the occupied territory, it should prove to be sufficient. In this same area today, 21 per cent of the frontage is already zoned for business purposes and no possible use has been found for over 7 per cent.

Curative Measures Needed

In the whole territory under discussion, both vacant and improved property, there are 44,105 lots, of which 9,680 are in the business classification and only 3,000 in use. If every residence and multiple structure lot were built upon, the demands upon the 6,665 vacant business lots would only absorb 1,585, leaving a surplus of over 5,000 parcels of property absolutely stagnant, which is nearly 9 per cent of the total area, meaning practically one lot in every nine vacant perpetually unless curative measures are adopted, because it has been placed in a zone classification for which it cannot be used. Here we face a tremendous economic waste—the dangerous prospect of having 5,000 lots in just one section of this city, each a 50-ft. unit, idle, a total frontage of 250,000 ft.

The false belief entertained by the property owner that the placing of his land in the business zone actually makes business property out of it creates an equally false temporary value. It is most conservative to state that the average market value today of this particular 250,000 ft. of frontage, now facing enduring idleness, is not less than $500 per front foot, or $125,000,000.

Overzoning of business, class "C," property within the city of Los Angeles will prove to be a great object lesson, as new contiguous areas are zoned, and cities unzoned will profit by the study of our experience.

Business Area Overdone

I offer no criticism for the planning commission when I speak of this city as overzoned for business. Mr. Gordon Whitnall and the commissioners whom he has valiantly served, embarked upon an uncharted sea in the zoning of this city, and in the great majority of instances the commissioners were obliged to accept conditions as they had been established by an unguarded public which required the creation of zones according to existing use, or tendency for use, rather than according to judgment.

I regret to state that much criticism must be directly laid at the door of certain realtors and professional promoters who constantly seek the zoning of residential property for business in order that they may exploit it, pocket the false value created by the establishment of a business zone and depart, leaving a trail of depleted residential value in their wake. Such a practice is in direct conflict with the Realtor's Code of Ethics and the man who profits by such practice should be dealt with accordingly.

There is a strange psychology, not founded upon reason, which, up to a certain point in city development, casts an apparent charm over property called business. The average citizen feels an inclination to insert his thumbs in the armholes of his vest and revel in the opinion that his particular possession zoned for business, is the real diamond, whereas his neighbor's lot zoned for multiple dwelling use or residential purposes is but imitation.

Zoning Cannot Perpetuate Values

Fundamentally, there is a natural, logical place in every city and its component parts for business, and the solid, enduring values are found existing in these logical sections. No amount of zoning can for any great length of time perpetuate false value in property not logically business.

The property owners who clamor the loudest to secure certain of our areas zoned for business will suffer most from their shortsightedness when natural development passes them by and leaves weeds of financial heartaches where legitimate income and advancing real estate values would otherwise have grown.

In my opinion it is unsound to permit

business usage mile after mile on long major thoroughfares, just because a relatively few blocks on that artery happen to enjoy the fundamentals essential to business development. This tendency of long shoestrings of so-called business frontage robs the property not possessed of essential business qualifications of its natural productive use for apartments, hotels and other income-producing use permitted in "B" zone. The conservative investor who analyzes the project in which he places his wealth, would not undertake to hazard a large financial expenditure in a multiple family structure possessed of the knowledge that his investment might be ruined by the entrance of obnoxious types of business on the surrounding property.

Compact Development

Whether we are discussing the central business center of a great city, or the business sections of districts removed from the major shopping center, we should, in my opinion, encourage compact business development and discourage business zoning elsewhere in the community. Major traffic intersections should serve as the guide to locating compact business areas.

The long stretches of territory between compact business districts on principal arteries will then naturally develop with the type of apartment or hotel which the territory justifies, because of the protection afforded by proper zoning. Greater values will then attach to both classes of property, to-wit: The compact area wherein business is permitted and to the area wherein business is forbidden.

Shopper's Preference

"Compact districts encourage shopping and elongated shoestring business streets discourage shopping." The reason for this is obvious: If the shopper elects to purchase a given commodity and fails to find the article sought at the first store entered, and if in close proximity there exist other stores carrying similar merchandise, then it is reasonably certain that the purchaser's money will be spent within the district; but if the shopper must go a mile to the next store and another mile to the third store, it is equally certain to discourage the most courageous shopper, and thereafter such purchases will be confined to business districts that are compact and therefore convenient. To illustrate: There is one prominent section in this city that needs large department store facilities, but no single store has been willing to enter the district unless assurance could be given that at least one other large department store would be located within easy walking distance, thus assuring the shopping habit on the part of the residents of that community.

I have referred to the existing evil of long arteries zoned for business, but not suitable for that purpose. Much of this evil can yet be corrected by properly educating the property owners in sections where the encroachment of unjustified business structures has not as yet progressed to the point of permanent injury. These owners can, I firmly believe, be encouraged to apply to have their frontage removed from the business zone and classified for its proper use.

This principle of taxation according to permitted usage has recently been partially applied in a section of this city and the result is most encouraging. Owners of property in non-income producing areas have to a considerable extent ceased their clamor for inclusion in multiple or business zone, knowing the strong probability of materially increased taxation. Certain entire blocks have sought to be removed from the multiple zone and reclassified for single family homes.

"A" zone, residential areas, should never be disturbed by reclassification, until the pressure of natural growth of the income producing "B" or "C" zone areas forces the change.

Centralized Business Areas

Summarizing:

(1) I believe a careful study should be made of all classes of cities that can reasonably be considered to have attained their growth, and the percentage of used business frontage ascertained, and that percentage should be applied in zoning communities of similar areas in this state.

(2) I believe all business zoning should tend to centralize business in compact districts.

(3) I believe a definite relationship from a taxation standpoint should be established between properties in different zone classifications.

(4) I believe much can be accomplished through educational channels to remedy existing evils in overzoned business territory.

I wish to acknowledge my appreciation to Mr. Gordon Whitnall of the City Planning Commission, for certain of the figures and percentages to which reference was made in my opening remarks.

In conclusion:

I believe that the realtors in this state

will fail in their duty as constructive citizens of their respective communities unless they place their individual and organized power of cooperation at the command of properly constituted planning commissions.

Not only should the realtor assist in perfecting zoning plans, but when once adopted and approved, the voice of the realty boards should be plainly heard in the proper halls when selfish interests seek to change them.

NATIONAL POLICY IN DEVELOPMENT OF WATER RESOURCES

By Herbert Hoover, Secretary of Commerce, Washington, D. C.

(Address before Columbia River Basin League, Aug. 21, 1926)

For the past five years the Department of Commerce has devoted much of its energies to study of the commercial possibilities in the development of the water resources of our country—inland waterborne transportation, power, irrigation, reclamation, and flood control.

The time has come when we must take an enlarged vision of the future. We have arrived at a new era in this development. We have need that we formulate a new and broad national program for the full utilization of our streams, our rivers, and our lakes.

Water is today our greatest undeveloped resource. Our streams and rivers offer us a possible total of 55,000,000 hp. and of this less than 11,000,000 has been developed. Of our 25,000 miles of possible inland waterways probably less than 7,000 are really modernized, and the utility of much of these 7,000 miles is mimimized by their isolation into segments of what should be connected transportation systems.

We still have 30,000,000 acres of possible reclaimable and irrigable lands. And these water resources lie in every part of the Union. The great basins of the Columbia, the Colorado, the Sacramento, the San Joaquin, the Mississippi, the Arkansas, the Platte, the Missouri, the Ohio, the Cumberland, the Tennessee, the Warrior, the Hudson, the Great Lakes, the St. Lawrence, and many others.

Almost unnoticed, the progress of science and engineering has revolutionized the possibilities of our water resources. Inventions in construction methods and tools enable us to economically deepen channels and safely construct great dams. These advances, together with improvements in water craft, enable us to transform the local packet boat into transportation systems for great trains of barges and ocean-going vessels. The discoveries in transmission of electricity now enable distant waterpower to be brought to a market as a vital contribution to the cost of developments for other purposes. We have emerged from the long postponement of national construction imposed by the war and reconstruction; we have recovered so greatly in national wealth that we now have the capital to compass such projects as our expanding needs require and our undeveloped resources make possible.

True conservation is to get our water at work. There are imperative reasons for it. Before expiration of the years required for major construction, we shall need more food supplies than our present lands will afford. Today there are many economic distortions in agriculture and industry due to the necessary increases in freight rates from the war, which can be greatly cured by conversion of our inland waterways into real connected transportation systems. Our population will increase by forty millions in the next quarter of a century. If we are to preserve the standards of this enlarged national family, we must place in use every resource we possess. Our race with the Malthusian theory can be won by such development.

All this has brought us to the threshold of a new era in utilization of these various resources of water where we must broaden our foresight, and determine great policies and programs. The great policy we need adopt is a resolution of vigorous development. The program is a problem of each great drainage.

Co-ordinated Long-View Development

We must no longer think in terms of single power sites or single storage dams or single land projects, or single navigation improvements; we must think (and thanks to science and engineering, we can think, in terms of the co-ordinated long-view development of each river system to its maximum utilization. We have also to face the regrettable fact that these great possibilities of development of water resources are fast drifting into the muck of litigation, political opposition and interstate quarrels, which could be solved by the determination of broad national program. Many of the problems are interstate and can be solved by no single local effort.

If we study each of our great systems,

we shall find that their possibilities lie each in its own case either in navigation, flood control, reclamation, irrigation or electrical power. On some drainages all these uses are available, in others but part of them. But, in any event, each system must be considered as a whole and organized to the maximum results.

The actual structures required for development of water resources in every case consist primarily of dams, canals, locks or channels, and their implacement without regard to the ultimate full development of all possibilities of a drainage results only in incurable losses. Nor do we need complete and detailed engineering plans. What we do need is immediate determination of the broad objective and best development of every river, stream and lake in our country in order that we do not undertake or permit haphazard development, whether public or private, that will destroy the possibilities of their maximum future returns. And likewise we must determine what structures shall be undertaken at once.

I am not proposing that all these things should be done tomorrow. At this moment we could not make economic use of the whole of this power or all this land, or all these inland waterways—but we will need the whole of it within half a generation. And at this moment we have the urgent need for beginning certain major projects which will in themselves require years for completion.

Some Major Projects

Perhaps my whole conception of a national policy may be made clearer if I review the situation upon a few of our great drainages where solution is most urgent. As Secretary of Commerce, I have during these last few years had special official responsibilities in the development of policies for the construction of a shipway from the Great Lakes to the sea; in modernizing the waterways of the Mississippi Valley; in the development of the Colorado River; in some aspects of the important developments in the interior of California, and in other similar problems upon the Tennessee, the Arkansas, and the Rio Grande and elsewhere. We have made some progress in preliminary steps—at least enough to vision the need for broader, more vigorous national action.

The Mississippi System

In the great basin of the Mississippi there lies the possibility of a development of the most fundamental economic importance—primarily navigation but also embracing many factors of flood control, reclamation and power. We have here a drainage upon which for moderate cost we can provide a modern transportation system of 9,000 miles of connected waterways, serving 20 states, furnishing a complete north and south trunk line across the nation through the lakes from Duluth through Chicago to the Gulf of Mexico, and an east and west system from Pittsburgh to Kansas City. Added to this are the great channels of the Upper Mississippi, the Upper Missouri, the Cumberland, the Tennessee, the Arkansas, and other streams. It has become of vital importance to the states which would be served that this system should be deepened and at once.

The modernizing of this entire system can apparantly be accomplished for an investment of under 125 millions of dollars. The nation has dilly-dallied upon it for years, and today even the work which has been well done lies in disconnected segments. Moreover, this system not only requires attention to direct improvement of navigation channels; it urgently requires a determination of plans to create headwater storage in some of its tributaries with a view to the control of floods, thus saving vast wastes of destruction and providing for an increase of low water flow not only as a contribution to summer navigation, but also for its direct returns in reclamation of land and power.

The Great Lakes System

The Great Lakes today are the greatest inland transportation system in the world, but at the present time the outward traffic to the sea has to pass through bottle-necks of 11 and 12-ft. canels. We know from an engineering point of view that it is entirely feasible to make every lake port an ocean port by deepening these canals to 25 or 30-ft. shipways. We know that such an improvement will decrease the costs of the exports of grain from 7 to 8 cts. a bushel. We know that this decreased charge will lower the cost to the farmer of reaching his foreign market and will be an addition to the farmer's profit. It will make possible the introduction of manufacturers' raw materials to the interior on a cheaper basis. This three thousand miles of inland waterways will serve some 18 states. We know it will tend to upbuild industry in the hearts of agriculture to the mutual benefit of both and to the better distribution of our population. Involved in this lakes-to-the-sea improvement is the possibility of developing some four millions of horsepower for our eastern states and Canada.

There are engineering and interna-

tional questions yet to be solved in relation to this great seaway project, and we are yet engaged in determination of the most advantageous route. I am confident the solution of these questions will be much advanced within the next six months, and our country will be able to embrace another item of a great forward program of water development.

We have in the Great Lakes another major problem in the restoration of the levels of these lakes from the shrinkage of the last seven years in order that we may restore to them their full possibilities of waterway transportation. There is also in this whole lakes problem sharp conflict over special and state interests; it involves complex international questions and difficult questions of states' rights, but its solution can be found in a broad program of engineering construction.

Colorado River

I know of no more perfect example of the need of determination of broad policies and of urgent execution of the first major engineering job than that furnished by the Colorado River. Here we have a great river whose basin lies in seven states, presenting the possibility that, given adequate storage of its enormous spring freshets, we could eventually add to our assets between 5 and 6 million acres of irrigated land and several million horsepower. This would be equivalent to the addition of a state to our Union almost as great as the State of Maryland. The Colorado River must also be the domestic water supply to many growing cities.

A multitude of problems present themselves at once in this river system. There is urgent need for immediate flood-control to protect the already developed communities in Arizona and California. There is need to provide storage for expansion of irrigation. There must be a provision of adequate domestic water supplies to southern California and cities in Colorado. There is need for the large power supplies that will be the by-products of this development. There is need to determine that the works erected for these immediate purposes should be a part of the co-ordinated development of the entire river, and, there must be a determination of the respective rights of the different states in their participation in the benefits from the river.

There are great conflicts over these projects and problems and I do not propose to enter upon the details of this complex question beyond the affirmation that the first step in this program—a great dam at Boulder Canyon and subsidiary works—is clearly an urgent and immediate necessity. It is one of the major water developments before us. I believe that in this case the entire outlay can be recovered from the sale of power and water. Many other great steps will need to follow because there must be a score of great dams before the whole of the Colorado Basin is developed and they may well require a whole generation for their completion. But above all, there must be a full co-ordination of development, so that any part undertaken whether by the government, by power companies, by the states, or by the municipalities, or the irrigation districts shall be part of a complete scheme whose full realization will result in the maximum utilization of the river.

Columbia River Basin

The Columbia River Basin should be embraced in a national program of major water improvement. In the upper stretches of this river there are two and one-half million horsepower and there is a possibility of adding 1,750,000 acres of land to intensive cultivation. Again this project involves interstate questions affecting the interest of four states. It involves the creation of large storage, the regulation of the flow of the river, and the proper and systematic location of dams for reservoirs and power. And there is here again conflict over all of these matters. Above all, in this situation, too, a co-ordinated program, definitely determined, that can be hewn to over a term of years, is the need of this moment.

Other Typical Major Developments

As I have said, there is a problem to be solved and a policy to be determined for practically every great drainage in the United States. I might cite the instance of the Tennessee and Cumberland Rivers, where, if adequate headwater storage were provided and the location of a dozen power dams were designated at the proper points throughout the systems, a total of about three millions of horsepower could be developed, the cities of Nashville and Chattanooga could be placed upon modernized water transportation, and the floods of the Mississippi mitigated. The devotion of a large part of the power which could be created here to the development of the electro-chemical industry is a national necessity for industry, agriculture and for defense.

I could cite the instance of the Arkansas River, where, if adequate headwater

and collateral storage could be provided, the river could not only produce a considerable amount of power but its destructive floods would be reduced, the loss of life and property would be safeguarded, and the low water flow of the river could be increased so as substantially to improve its navigation possibilities. Again, this river involves the rights and interests of six states.

Upon the Rio Grande River a large development has already taken place but in this a great expansion of irrigated land and better control of the river's waters could be obtained by systematic headwater storage. This project involves again the interest of three states. A deepening of the Hudson River to ship depths will improve our greatest national terminal. Again we have need of deepening and improving our inter-coastal canals—as a part of our great inland waterway systems.

I could point out the situation in the great interior valley of California where improvements for navigation are needed and where already the advance of irrigation and reclamation has absorbed the total capacity of storage now constructed but with great reservoir sites still available. From them better control of floods and great expansion in the acreage to be brought under irrigation could be had. Here again there is bitter conflict among various interests which could be allayed by definite development of co-ordinated engineering plans and a program of major development.

I could travel from river to river, pointing out the need for comprehensive co-ordinated plans for all river and lake systems and in many cases the need for immediate action.

Finance and Ownership

The question at once arises as to who is to finance and own these great developments. I believe that we have by legislation and practice over many years already determined the major principles of this question. I have said that the development of these rivers and lake systems involve either the development of navigation, flood-control, reclamation, irrigation or electrical power. Some of these systems involve only one kind of development—some several.

Out of the federal responsibility for interstate commerce we have long since adopted the policy that navigation should be improved at the direct cost of the federal government, but with contributions from local governments where the object is more local than interstate. The federal government has long since contributed directly to flood-control in support of local and state action. The federal government has given assistance by loaning the capital for irrigation and reclamation works, but with the presumed provision that the cost should be recovered from the land.

Other forms of finance lie in the undertakings of irrigation or reclamation districts; the undertakings of municipalities in the procurement of their domestic water supplies; the undertakings of states and local parties in flood-control and navigation works and in the great undertakings of our hydro-electric companies. Every river system and often different developments upon the same systems present a different proposal as to which of these agencies shall undertake or participate in the undertaking and in what proportions. We have here also a problem of determining the limits of private and public development. It appears to me obvious that where the major purpose of a given development is navigation or irrigation, reclamation or flood-control, then either the federal government or the states or some particular local district must assume the burden and ownership of the permanent works.

Our problems become more complex when electrical power is involved. It is my own view that the federal government should not go into the business of either generating or distributing electrical power. There may be some special cases, but our general policy should be against it. Where power is a by-product of dams for other major public purpose such as navigation, etc., then the federal government should lease the power rights so as to recover as much or the whole of its total investment as can be. Where the development is for power only then it should be leased under provisions of the Federal Water Power Acts which amply provide for control by the government. Where such major electrical development may in minor part affect the other purposes of irrigation or domestic water storage, etc., then the rights of these users can be protected by conditions in the leases and those acts.

The federal government cannot completely enter into the business of generating and distributing power for many reasons, one of the least of which is that it cannot secure for isolated blocks of power such a diversity of load that it will yield a high daily load factor and consequent maximum use. That can be obtained only through our large inter-

connected power systems. The regulation of our utility rates to protect the public is the responsibility of our state governments.

That the federal and state governments should carry some portion of the burden of the development of navigation, flood-control and irrigation is founded upon sound policy. It is warranted because it is not alone the direct shipper who received all the advantage of water borne traffic; it is not alone the owner of irrigated land who benefits from its production; it is not alone the drowned individual who loses by floods, or the settler in bottom lands who benefits by its control. The neighboring village, distant cities, the state and the nation at large gain some part of their livelihood through furnishing commodities, transportation and a score of other services to their immediate beneficiaries. More people will make a living out of these developments who actually live apart from these acres and these river banks than the numbers who live upon them. Therefore, in these large fundamental public works which have these indirect values not only the state but the nation should bear some part of the burden, either through direct expenditure or the lending of money as a particular case may best be handled.

Enlarged Federal Expenditure

Today we are expending on isolated works under the Rivers and Harbors Appropriations and under the Reclamation Act sums aggregating perhaps at most 65 millions a year. It is my own view that the federal government can well afford to enlarge its financial program in contribution to the great permanent structures; to pour the concrete and dig the channels for this great development, and to organize such collateral support from the states and collect such returns in by-products as sound procedure and good sense will offer. An increase by the Federal Government beginning at $25,000,000 and raising to $100,000,000 a year together with the collateral expenditure of states, local communities and the hydro-electric companies would complete many of our most pressing projects in the next ten years. Much of this expenditure would be directly recovered from land and from leases of by-product power. It is all of it a capital outlay not a disappearing expense.

Realization of these plans will bring economic well-being measurable not in millions but in billions. We could for the immediate projects that lie before us even find a return in money by the increment in federal income tax alone, for the growth of national income and wealth would finance and more than warrant any such national outlay. We are all engaged in the great effort at tax reduction, but a soundly run business house not only looks to its expenditures but it looks for increased revenues. A nation can reduce its tax-rate by increasing its wealth and thus causing a spreading of the burden. These are reproductive works we are talking about. They are not charity to any locality.

We have fortunately grown out of the period of the pork barrel in river and harbor improvements. The distinguished action of Congress by which the broad distribution of appropriations is left to the United States Engineers removes from all these proposals the charge of political waste. To have definite policies and plans for each drainage will be a further assurance of efficient expenditure.

Organization

One of the primary requirements to a national advance in these questions is better organization, both for determination of plans and for their execution. I hesitate to discuss the subject because it presents such an appalling picture of what is otherwise a very effcient nation. Our first need is complete engineering studies of every drainage that we may have the basic fact upon which to determine engineering plans, we already have such information but in no case complete. Our second need is organization to determine a procedure and to co-ordinate interests.

I have mentioned that in most of these projects there is involved a relationship by the federal government, often by several state governments, by municipalities, by irrigation, reclamation and flood-control districts and by power companies. I might add that some of these projects involve international relationships with Mexico and Canada. I have mentioned the quarrels, litigation and political obstructions in progress with respect to many of these projects. I may add that there are even more relations to be considered in these projects than might appear from even this description. There are four independent federal administrative departments concerned; there are two or three different administrative departments in each state and there is conflict of opinion between representatives of counties, municipalities and districts. Congress and committees thereof, the governments and legislatures

of several states are also concerned, not to mention town councils and district boards. There are also involved the hydro-electric companies.

There is, therefore, vast complexity of opinion and interest which must be brought into agreement on policies and there are except in partial cases no agencies that can pull these policies into some definite form.

Furthermore, as I have mentioned, finance in many cases must be erected by securing the co-operation of federal, state, municipal and district governments, and often the power companies. There is nobody to formulate financial plans and to arrange the vast amount of detail which their set-up involves. Unless we can get something more effective by way of organization of the factors involved in the solution of these problems we are not going to get very far.

Nor am I about to propose any extension of federal bureaucracy. I want to see more local responsibility. Moreover, we are a democracy and we must proceed by persuasion.

Therefore, my conclusion is that we should take a lead from the successful history of the lower Mississippi River Commission where troubles were of the same complex nature but through whose skill over a term of years we have at last evolved peace, finance, construction, navigation and flood-control on the lower river. I should like to see a commission set up separately on each of these great drainages, on which not only the federal government but also state governments concerned could be represented and which would also include independent technical members. I would not give to these commissions the power and task of spending money, of construction or administration. We have efficient engineering corps in our federal and local governments for technical determinations and the execution of construction can be administered through existing agencies of the government or by way of federal contributions to the state or districts. The job of these commissions should be to consider the engineering data, to think, to plan, to devise, advise, coordinate, negotiate, persuade and set upon the obstreperous. They should determine major lines of policy to be undertaken; they should organize the financial support and recommend what administrative bodies—national, state or local—should undertake execution (if they are governmental works) and they should make recommendations to Congress or state legislatures for action. We have small beginnings of such organizations in the Lower Mississippi Commission, the Colorado Commission, and the St. Lawrence Commission.

We require no extension of the basic authority, for under the federal control of navigation, power and public lands, together with the state water laws, we have enough authority to stop almost anything even if we cannot move forward. By these means we could thus resolve our problems into their regional character, build them upon regional knowledge and regional support. We could come to conclusions and plans around which all elements could rally for effectual action.

Our third need is better organization of our agencies for construction and administration, with a view to reducing conflicting agencies in the Federal Government and with a view to building up a center point for real and constructive national policies and for administration in engineering and construction and greater economy in expenditure, Secretary Work and I have many times recommended that all of our different federal activities in public works be concentrated into a Public Works Division of the Interior Department, with our able army engineers assigned to that section in peace time. All this to be under direction of an Assistant Secretary of Public Works.

A plan such as I have outlined follows the essential principles of good administration and sound public action. It separates the advisory and the judiciary questions from administrative and executive questions. In the former we need the value of many minds in order to secure the best judgment and widespread co-ordination and co-operation. In execution we need single-headed responsibility. Our national development will be advanced by many years and executed at much less cost if such organization can be brought about.

THE RAILWAY AND THE CITY PLAN

By C. F. Loweth, Chief Engineer, C. M. & St. P. Ry., Chicago, Ill.

(Paper before 18th National Conference on City Planning, Jacksonville, Fla.)

The railroad is a fundamental element in a city plan since its location has an influence upon the city's growth, but this interdependence between the railroad and

the city has not been as generally recognized as it should be and there is need of a better mutual understanding. Each city presents an individual problem which should be studied separately, and to which no formula applies; hence the adoption of any plan should follow an exhaustive scientific study of the particular problem.

The writer, however, does not agree with the statement which is sometimes made by city planning engineers that "the greatest problems confronting railroads today are those of terminal operations in cities." It is admitted that these problems are great and far-reaching, that there is need for a more prompt and less expensive handling of traffic through large cities, but there are many other problems entirely aside from any connection with city planning which are of equal or greater importance than terminal operations in cities.

Through Freight Traffic and Planning

In a recent paper by a city planner it was stated that the paramount objectives to be obtained in the relationship of the railroad to the planning of a modern city were through freight traffic, local carload traffic, less than carload traffic and passenger traffic. The paper commented on the situation at St. Louis, particularly that 85 per cent of all freight entering that city is through traffic. This does not seem surprising and is equally true of many other cities, large and small.

There are probably few cities, if any, where so large a proportionate volume of through traffic would result in the operating difficulties existing in St. Louis and vicinity. Here we have a railroad gateway for 26 railroads which extend in all directions, a complication and restriction of railroad development incident to a multiplication of state and municipal control, a large fan-shaped city and two large rivers.

Several cities might be mentioned, larger and smaller than St. Louis, where proportionately larger volumes of through traffic are passed through with much less interference and confusion, due to railroad development not having been as restricted as it is at St. Louis.

Based largely on this extreme illustration, the conclusion is drawn: "In a city where through freight constitutes a large percentage of business of the railroad terminals and becomes an obstacle to efficient operation of these terminals for local purposes there should be a separation of function." This separation of function is proposed to be made by a belt line "to be built well outside of the present and probable intensive urban growth." Then follows the admission that such a remedy in St. Louis would involve a large investment, as most certainly it would. Moreover, the construction of such a belt line would be but the beginning of a much larger investment, which would involve all of the railroads with which it connected.

A belt line to function as here proposed, if carried to its logical and economical development, would necessitate the construction of new division freight and engine terminals outside the belt line by all the connecting railroads. For the most part, these new terminals would be duplications of existing facilities which would become superfluous and be wholly or partially abandoned.

The aggregate cost of these new facilities to the connecting railroads would undoubtedly exceed that of the new belt line. Nor is this all, for in most cases the shortening of main line operating divisions would adversely affect trainmen's and enginemen's schedules and many other operating elements so as to add largely to the cost of moving traffic to the belt line.

The abandonment or removal of freight and engine terminals is always an expensive proposition; it disarranges and shortens the home layover of many railroad employees, and on this account is objected to by them and also by most other local interests. In a number of states attempts have been made to effect legislation which would make it impossible to abandon or relocate railway terminals.

Outer Belt Lines Expensive

Where through traffic can be diverted over a belt line which is under the same control as that of the trunk line, the traffic may often be expedited, but if the belt line is operated by an organization independent from that of the trunk line, and is handling traffic for several railways, delays as well as additional transportation costs are inevitable. For these and other reasons which there is not time to mention, an outer belt line to take care of through freight traffic will involve prohibitive investment costs, large additional operating expenses, increased delays and other difficulties. The building of an outer belt line would run through suburban districts which ought to be preserved for other purposes and would tend to multiply railroad lines and so hamper and restrict city growth and development.

Concerning the question of local carload freight, the paper lays down the

rule that "the principal objective to be considered in handling this class of traffic is the minimum time between the shipper (or consignee) and the road haul;" then follow three rather half-hearted suggestions as to how this could be accomplished, viz., the outer belt line, an inner belt line, and a joint terminal company.

Assuming for the present that these suggested remedies would accomplish the "principal objective" stated, of saving time (which they would not), it is not apparent how they can be related to the fundamental elements of a city plan. Doubtless, there may be found in all large cities, instances where individual car movements are slow and involved, but this is true only of a quite negligible proportion of the whole. The cures proposed would quite certainly be worse than the disease, from the standpoints of shippers, railroads, and lastly, but quite important at this time, the city plan.

In the matter of so-called l.c.l. or package freight, the objective is again stated as saving time, plus the hauling on city streets. Let us consider the problem of a city of the first class, of 200 square miles more or less, and several thousand shippers or receivers of freight involving individual shipments aggregating hundreds of thousands daily, these shipments to be classified and loaded in several thousand cars to be dispatched, daily, by from 10 to 20, or more, railroads to several thousand destinations in all directions. The wonder is the job is done so well. The magnitude and complexity of the problem calls for much far-reaching experience to evolve a better method. Railroad men realize the present plan may not be the best and are giving to it the consideration of many experienced operators. The solution, when arrived at, must be made to fit in with the city plan, or at least do no violence to it; on the contrary, the city plan cannot settle this problem.

Union Passenger Terminal and City Plan

As to passenger traffic, the statement is made that, "the question of a union passenger station as distinguished from separate passenger stations for individual railroads is usually the one great public issue insofar as the city plan is concerned." And so it follows that a union passenger station is frequently made the outstanding feature of a city plan. In most cases, this is entirely unnecessary, may be detrimental, is oftentimes impracticable, and certain to involve great expense. However, a union passenger station adds weight and apparent dignity to a city plan; it diverts attention from the more practicable but probably more difficult problems. It has a strong appeal because the public is led to believe that a proper city plan is in large measure dependent upon a union station, and especially is it attractive in that the city is not expected to share its cost.

Again it is stated that "a union station can only be justified: (1) Where there is a considerable volume of interchange of passengers between railroads, said passengers merely passing through the city as quickly as possible between points beyond such city, or— (2) where the location of individual stations is a considerable inconvenience to a large number of local patrons."

The writer believes that neither of these considerations is fundamental. There are comparatively few railway connections where there is a considerable volume of interchange of passengers who are interested in transferring quickly from one railroad to another. Where passenger traffic is sufficiently large to have much interchange of this kind, the proportion of passengers who begin or end their journey at that station, or stop over for a portion of a day, is so much larger as to make the volume of the other type of passengers insignificant. There are few places where the volume of such interchange would be a material factor. Transferring from station to station is now both cheap and rapid, and furnishes a pleasant break in a tiresome rail journey. Union stations in large cities are so large that transfers between trains in them are not made quickly or easily.

A passenger station " so located as to be of considerable inconvenience to a large number of local patrons" may or may not be an unfortunate situation; certainly such a condition should have consideration, but it may well be that the cost of a more convenient location would be out of all proportion to the benefits, would result in a considerable dislocation of local interests, and restrict or distort the growth and development of the city. Passengers are but a small minority of the entire population, the convenience of which must be considered in the city plan. Union passenger stations should be considered for more pratical reasons than those usually advanced in city planning projects. The abandonment of two or more passenger stations for a union station involves an expense always very great and in many cases prohibitive. Sentiment as well as false and petty civic pride are too frequently

the underlying reasons advanced for union station projects.

The writer does not agree with the statement frequently advanced that, "A union station in a city of considerable size should generally be close to the business district." If so located, it will in time interfere with the normal growth of the business district. The city of Chicago is now endeavoring to push its south-side stations farther from the "Loop" district; Philadelphia is contributing a large sum to the plan of moving the Broad Street station out of the congested center of the city to a point west of the Schuylkill river, and the New York Central station at Buffalo is to be located farther from the business district. Other similar instances in both large and small cities might be mentioned. Surely in the light of the experience at hand it would be most unwise to crowd a new station into the heart of a growing city.

Union Stations Result of Early Railway Development

Union stations are not, generally speaking, a product of modern city planning; they are the result of early railroad development when the railroads were shorter, through car movements less, and the transferring of passengers was greater. Instances of the merging of several passenger stations into union stations are rare. It is well to note here that there are some so-called union stations which are union in name only and are not used by all railroads. The list of cities served by two or more passenger stations is much larger than of those having union stations. It is also worth noting that the first list includes those cities which have shown the largest increases in population and appear the more progressive. This fact may or may not have any connection with the question of union stations, but the coincidence is striking.

With union stations there would remain the need of retaining many outlying or local stations, the location of which would serve many patrons better than other locations; in fact, in many cases passengers would travel longer distances in going to union stations. In such cases the result would be more stations with multiplied confusion and expense. Existing stations, though small, may not as a rule be discontinued without the permission of state and city, which is seldom granted.

It has come within the writer's experience to contest the demand for a union passenger station in a city of a population of about 30,000 which has not increased in 30 years, the cost of which would have exceeded $3,500,000, to be divided between three railroads. In another case, in a slightly larger city, the two existing stations were ample in size, well located and fairly modern in convenience; the meetings with the local committees were held in the city hall, which was more than 40 years old, a veritable fire trap with gas jets along the side walls and primitive toilet facilities which were antiquated and inadequate at the time the building was erected. In neither of these cities had the authorities made any effort to carry out other quite minor and inexpensive details of the city plan. Other similar, though less extreme instances, might be mentioned.

It is a matter of common knowledge that steam railroads have lost a large volume of passenger traffic to the private automobile and bus lines and it is not apparent that anything they can properly do would enable them to recover any large part of that loss or stop its further inroads. In view of the dwindling revenues from passenger traffic there is no justification for increasing passenger terminals where existing ones are serving their purpose with reasonable satisfaction and without congestion.

The suggestions for union passenger and freight stations, belt railroads and union freight classification yards intended for joint use by several railroads, fail to take into consideration several important factors. They overlook the fact that these agencies result in a large division of responsibility. When a railroad turns its traffic over to a belt railroad, a union freight station, a common classification yard or another joint agency, it loses control of it. Shippers must look to the intermediate agencies to remedy delays and other complaints. A duplication of agencies for the performance of a given job is certain to result in delays, and increased expense and to be otherwise objectionable. Individual initiative has always been the mainspring of human progress. There is individual initiative in commercial and industrial enterprise, as a result of which has come the wonderful advancement of the present day.

Similar freedom for service is necessary for the railroads; they desire it and are willing to assume the responsibilities accompanying it. More and more the railroads are being deprived of individual responsibility for efficient and low cost

service by a multitude of regulations and restrictions of all kinds, many of which are unnecessarily severe and conflicting. The railroads have nothing to sell the public other than service at prescribed rates; they would be glad to give passengers and shippers the best service possible, but this cannot be done when intermediary agencies are introduced. Federal legislation the last few years, both in effect and at present proposed, has been with a view of reducing and simplifying, rather than multiplying railroad transportation agencies. All well considered city plans will take these things into account.

The Grade Crossing Problem

The large number of grade crossings of streets and highways with railroad tracks is a problem of city planning and a matter of great concern to both municipalities and railways. This concern is in no wise lessened by reason of the exceedingly great cost of grade crossing separation. It is certain that the elimination of grade crossings by separations or relocations cannot be made a general remedy for avoiding the delays and dangers of grade crossings. It is roughly estimated that it would cost more than twelve billion dollars to separate all the grade crossings in this country.

The state of New York has recently authorized the issuing of about $300,000,000 of bonds to eliminate, not the greater number of the grade crossings in the state, but only a comparatively few. These bonds are to be issued in small amounts through a long term of years and are to be used to meet the state's share of the cost of grade separation, and to advance funds under long term agreements to municipalities and railroads to enable them to finance their share of the cost of such improvements. It is admitted that the municipalities, as well as the railways, cannot undertake the financing of an increased amount of grade separation improvements without large aid in this form from the state. The state of New York is exceptional in its ability to finance an undertaking of this kind, as are also the majority of its municipalities and its railroads. Certainly few, if any, other states with their cities and railroads could undertake any such plan.

It would be an error to assume that the grade crossing problem principally concerns the cities or suburban districts where there is a maximum of traffic over the tracks and the highways, for there is an insistent demand on the part of state, railroad and highway commissions, counties and towns for grade separations and grade crossing protection in the less congested districts. That there is some warrant for this is due to the fact that many grade crossing accidents occur on outlying and rural grade crossings.

In view of these conditions, those interested in city planning can bring about larger immediate and worth-while remedies for the dangers and delays incident to grade crossings by a greater co-operation with the railroads in providing crossing protection, in the removal of obstructions to the view such as signs, trees, etc., and the enforcement of such stop and other regulations as may be practicable. Even more effective would be the closing or vacation of unimportant or lightly used streets and roads crossing railroads. There are many such where no hardship would result. With the rapidly moving auto and truck of today, a detour of a few blocks is of no moment, especially when safety of life is at stake. Experience shows that these less used crossings are likely to be the more dangerous. In several states recent legislation has made it possible for state railroad commissions to close highways where they cross railroads unnecessarily, where the danger is great, or where the highway traffic can be readily diverted.

Effect of Zoning on the Railroads

Zoning is a matter of great interest to railroads. Their prosperity is, in a large degree, tied up with the industrial development of the districts through which they run. Industrial development for the most part, must be in the proximity of, if not adjacent to the railroads. There appears to be too frequently a tendency to restrict the commercial and industrial development along railroads through cities. Railroads have been active in promoting the development and location of industries along their lines. Zoning has, in some cases, made this increasingly difficult, to the disadvantage of both the railroad and the city.

There is evident a healthy sign of increasing attention to the attractiveness of industrial buildings. In a greater measure than ever before are industries and large commercial enterprises being housed in buildings of pleasing appearance with a setting of shrubbery which make them attractive and not out of keeping with fine residence districts which may be adjoining.

DESIGN OF CONCRETE ROADS

By H. E. Surman, Engineer of Design, Illinois Division of Highways, Springfield, Ill.

(Paper read at 1926 meeting of American Association of State Highway Officials at Pinehurst, N. C.)

If the question were asked ten years ago "How many miles of concrete roads now in existence will successfully withstand modern traffic loads," the answer probably would have been "All of them." If the same question were asked today, the answer would be "All roads constructed according to proved methods of design resulting from the Bates, Arlington, and Pittsburgh Test Roads, and other recent researches and investigations." What will be the answer to the same question ten years hence. It would be very interesting, and it would result in the saving of many millions of dollars if the question could be answered today.

The results of research work, as well as extensive tests carried out in the Bates, Arlington, and Pittsburgh experiments during the past five years, have revolutionized the design of concrete roads. It is enlightening to study the change brought about in the design of the pavement slab by these tests, as tabulated by the U. S. Office of Public Roads. From 1917, the first year that the Federal Aid Act became effective, to 1920, inclusive, all plans submitted for Federal Aid projects for concrete pavements were on the basis of a thin edge or uniform thickness design. In 1921 there were 251 thin edge or uniform thickness designs and 4 thickened edge designs; in 1922, 396 of the former and 122 of the latter, and in 1925, 105 thin edge or uniform thickness designs and 418 thickened edge designs. According to the tabulation for the year 1925, the 9-6-9 pavements predominated with the 8-6-8 sections second, and the 9-7-9 third.

The three most important factors in designing a concrete pavement are: Maximum load with its resultant impact, character of subgrade, and climatic conditions.

In nearly every state, maximum axle or wheel loads are specified by law, the most common maximum limit being an 8 ton axle load or 8,000 pound wheel load. In fact, this load limit has been so generally used in the design of pavements for the past several years, and so many millions of dollars have been expended on the basis of that limit, that it would seem very unwise to permit an increase in the wheel load at this time. In Illinois, for instance, more than 3,500 miles of concrete pavements have been constructed since 1922 on the thickened edge theory of design for a maximum wheel load of 8,000 pounds, and the investment in those pavements alone exceeds $100,000,000. Add to this the expenditure in all of the other states, and it can be readily seen that an increase in the maximum wheel load would seriously jeopardize an investment of several hundred millions of dollars.

The fatigue of concrete due to numerous repetitions of the maximum load is a matter which must be considered. Many tests have been made to determine the stresses developed in concrete pavements due to static loads and impact. It has been conclusively proved by independent tests that fatigue can be disregarded so long as the allowable tensile stress used in the design of the concrete does not exceed 50 to 55 per cent of the modulus of rupture. The allowable working tensile strength used in designing concrete pavements is generally taken as 300 lbs. per sq. in. Results of tests to determine fatigue in concrete due to impact stresses indicate that this is well within the limits of fatigue due to static loads and can therefore be disregarded so long as pavement surfaces come within the limits of the ¼-in. specification for smoothness. If, however, there are variations in the pavement of as much as ⅜-in., then the element of fatigue due to impact becomes a serious matter. This emphasizes the importance of securing smooth pavements within the limits of ¼-in. variation.

The character of the subgrade should play an important part in the design of concrete pavements. While there has been a large amount of research and investigational work on this subject, this still remains a very uncertain factor in concrete paving design. The chief aim of additional investigations should be the determination of some rational method of evaluating different subgrade soils and the prescribing of methods for strengthening the so-called poor soils so as to make them suitable as a foundation for concrete pavements. It is highly important that the subgrade be drained thoroughly, and, in many cases, drain tile can be used to carry away free water. It has been shown conclusively, however, that drain tile has no effect in reducing the capillary action of water in the soil.

Climatic conditions affect the design of pavements in two ways: First, by causing expansion and contraction of the

pavement itself, and second, by causing variations in the volume of the subgrade. Concrete such as is used in pavements has sufficient compressive strength to resist forces set up due to expansion, but it is not strong enough to prevent transverse cracking due to the tension set up in the concrete during contraction. In Illinois no transverse joints are provided except adjacent to bridges, where a 4-in. joint is placed on each side of the bridge so as to permit the structure to act as an independent unit. During the past 7 years more than 5,000 miles of concrete pavements have been built in Illinois without the use of transverse joints at regular intervals. If a committee of competent highway engineers should make an inspection of the entire system so constructed, it is to be doubted whether they would come to the conclusion that transverse joints at frequent regular intervals are necessary.

The chief arguments against the use of transverse joints are first, added cost, and second, the fact that their use generally results in a rougher pavement surface. The maintenance cost of properly protecting a transverse crack is no more than the cost of protecting a joint, and it can be safely concluded that a natural crack will cause stresses to be transferred from one side of the crack to the other, whereas, a pre-cast joint will not transfer the stress from one side to the other unless some sort of dowel is provided. While occasional small "blow-ups" have occurred in the Illinois pavements due to excessive heat in the summer months, these have been by no means serious, and in not a single instance has there been a case where traffic has been delayed because of such "blow-ups." These have not averaged more than 10 to 20 for every 100 miles, and have not been serious enough to cause a change in the policy of omitting transverse joints. Variations in volume of the subgrade due to climatic changes should be predetermined so that proper precaution can be taken to remedy the condition by adequate subgrade treatment if deemed necessary.

The cross sections for concrete pavements used in Illinois were developed from the Bates Road Tests. An 18-ft. pavement has a 9-6-9 thickness in the rural districts as well as in all other parts of the State where heavy trucks are not expected to exceed 200 units per day for a considerable period of years. This is the cross section which showed uniform signs of failure in the Bates Tests under loads considerably greater than permitted by law, and therefore proved under actual traffic loads that it is a balanced design.

The pavement is divided at its center by means of a deformed metal joint. One-half inch deformed bars, 4-ft. long, spaced 5-ft. apart, across the center joint hold the two halves of the pavement together, and also assist in transferring stresses from one side of the pavement to the other. The deformation in the center joint is also a big factor in distributing stresses across the joint. A ¾-in. round smooth bar is placed 6-ins. from edge of the pavement. The duty of this bar is to transfer stress across the transverse cracks or construction joints, and has the effect of eliminating all corners from the pavement. The bar is coated with heavy oil so that the concrete will not have a firm grip on it. This is very important, as otherwise the bar would fail when transverse cracks appear in the pavement due to contraction.

The chief functions of the center joint are first, to act as a hinge so as to permit the concrete pavement to come more nearly in contact with the subgrade at all points; second, to transfer stresses from one side of the joint to the other so that the joint will not be a plane of weakness, and third, to prevent longitudinal cracks.

The 20-ft. pavement design used in Illinois has a thickness of 9-7-9, the 9-in. edge thickness extending for a distance of 1-ft. from the edge and tapering to the mid-portion thickness in two feet additional. It is a balanced design as computed on the theory of proportional section moduli. The edge bars are increased in this section to ⅞-in. and the design of the center joint remains the same as for the 18-ft. road. This section is used within a radius of 50 miles around Chicago and near other large cities having a population greater than 60,000. It is not intended that this section should permit heavier loads to travel upon the road, but it is for the purpose of providing a greater factor of safety against fatigue due to a much greater frequency of maximum weight truck units. It is believed also that the additional 2-ft. of width will cause wheel loads to travel at a greater distance from the edge and this fact will have a very pronounced effect in increasing the life of the pavement. The width of shoulders on the 20-ft. pavement design is increased to 10-ft. on each side so as to permit of a future widening to

40 ft., as well as to provide a parking place for vehicles that desire to stop along the road.

The 40-ft. concrete pavement designed to carry 4 lines of traffic is designed on the same principles as the 20-ft. section and consists essentially of two 20-ft. pavements butted together and separated by a deformed metal joint. This section is being used in the metropolitan area around Chicago. The surface is divided into four 10-ft traffic lanes by the application of a 4-in. band of asphaltic paint over the three longitudinal deformed joints. Streets in cities and villages upon which 40-ft. pavements are constructed should be wide enough to permit parking of vehicles outside of the limits of the 40-ft. pavement. If such cities or villages desire to widen the pavement, the minimum width that should be considered is 56-ft. from inside to inside of curb, as this will permit 8-ft. on each side for parking purposes and will allow for the free movement of four lines of traffic. Any paving design which does not take into consideration the need for that extra width within the more densely populated districts is falling far short of its object.

It is generally conceded that 18-ft. should be the minimum width of pavements in rural districts and near smaller cities. In the vicinity of large centers of population, however, 20-ft. should be the minimum 2-lane traffic road. For pavements carrying more than 2 lines of traffic, the widths should be in multiples of 10. It is assumed that 4-lane traffic roads are built only near large centers of population and therefore 40-ft. should be the minimum width considered for such a road. A 3-lane traffic highway has very little justification, and should never be built except under conditions that make it impracticable to construct a 40-ft. pavement. Three-lane traffic roads are dangerous during times of nominal traffic because they cause a contest for the third traffic lane between vehicles moving in the opposite direction. When such a highway is crowded with traffic, it is no more efficient than a 2-lane traffic road. If conditions are such as to warrant the construction of the pavement for more than 2 lines of traffic and there is not enough money available to construct a 4-lane traffic road, it would seem to be the best policy to construct a 20-ft. pavement for the present and widen the same to 40-ft. when the money is available.

The crown on concrete pavements should be just as flat as good drainage of the surface will permit. It might seem strange that the crown for the 20-ft. pavement is only 1-in., whereas, the crown for the 18-ft. pavement is 2-in. The reason for this is due to the fact that 20-ft. pavements are built near large centers of population, and it is expected that they will be widened to 40-ft. or more within their lifetime. If a 20-ft. pavement having a crown of 1-in. is widened to 40-ft. by adding 10-ft. to each side, the resultant crown will be 4-ins., whereas, the same 20-ft. pavement with a crown of 2-ins. would result in an 8-in. crown for the 40-ft. width, which is excessive for the comfort of passengers using the outside traffic lane. The 18-ft. pavement section is given a 2-in. crown because it is assumed that not many of these pavements will be widened within their lifetime, although now that concrete surfaces are being constructed smoother than ever before, some consideration might be given to the reduction of this crown.

All properly designed pavements should provide for adequate superelevation on all curves up to 6,000-ft. radius. The maximum superelevation for any curve should be 1-in per foot of width. All pavements constructed during the last 7 years in Illinois have been built according to our superelevation policy. There is no question but that proper superelevation of curves adds greatly to the comfort and safety of the users of the road.

Adequate widening on curves is another safety feature which should be given careful consideration. The practice used by different states varies widely. The conditions affecting widening are approximately the same throughout the country, and there is no reason why greater uniformity should not exist in this feature of pavement design. Vehicles traveling around a curve occupy more space laterally than on a straightaway In addition to this, there must be an extra allowance in width because of the fact that vehicles meeting on curves tend to stay farther apart than when they meet on tangents. Further allowance must also be made for the ever-increasing size of motor passenger buses and it should be assumed that two such buses will meet on a curve. Another consideration is the trailer, which demands extra width because it will not track with the car ahead which is propelling it. The amount of widening required varies with the radius of curvature, and should not be less than 2-ft. for 1,000-ft. radius curves; 3-ft for 400-ft. curves; 5-ft. for 200-ft. curves, and 7-ft. for 100-ft. curves.

Wherever practicable, horizontal curves should have radii greater than 1,000-ft. because it is not necessary to widen above that limit.

The question of sight distance is an important consideration in the design of horizontal and vertical curves. Wherever practicable within economical limits, the minimum sight distance should be 400-ft. Horizontal and vertical curves should be made long enough so that this minimum sight distance will prevail at all points. In most cases it is practical to obtain a much longer sight distance than the 400-ft. minimum, and a careful policy regarding horizontal and vertical curves should be formulated so as to give the vehicle operator the benefit of the maximum sight distance and therefore the greatest amount of safety at all points along the road.

This paper is not intended to be a complete analysis of all essential features entering into the problem of concrete road design, but its object is to call attention in a brief way to the more importan problems with which the designing engineer has to deal. There are many other features of lesser or possibly equal importance which merit consideration.

The main object of pavement design, however, is to obtain a well-balanced section that will withstand maximum allowable traffic loads within its estimated lifetime, and at the same time provide for the safety and convenience of the traveling public.

RECREATION SURVEY OF BUFFALO

American industrial cities should find much practical value to them in planning recreation for all their citizens in "The Recreation Survey of Buffalo," a volume of 369 pages, illustrated with 38 maps and diagrams.

The Survey was begun in a small way in 1921 by the Social Welfare Conference, later reorganized as the Buffalo Council of Social Agencies. It was concluded under the supervision of the Buffalo City Planning Association, who selected as their expert advisor for this work, L. H. Weir, field secretary of the Playground and Recreation Association of America. A large group of volunteers assisted in collecting the facts, and had generous co-operation from city officials, social workers, citizens and organizations. This unusual measure of co-operative work is an outstanding feature of the survey.

A complete picture is drawn of the city's existing recreational facilities, public and private, and is contrasted with the standards which Buffalo should meet to provide adequately for the leisure time of its people. Much of the philosophy of public recreation is contained in the pages of the survey, which deals with the relation of leisure time to the distribution of population and to the home and industrial life of the city.

Commercial recreation is discussed; Buffalo's laws for the control and regulation of such recreations being given in full. Other topics are "Organization and Administration of Public Recreation," which presents an excellent set of standards and principles, "Private Facilities and Activities" and "Foreign Population Studies." The survey of church recreation is comprehensive.

Since Buffalo has more than three times the area in streets that it has in parks and playgrounds, a more extended use of city streets as recreation areas is planned.

The work of the Buffalo Academy of Fine Arts is described, as is that of the Buffalo Historical Society and the Buffalo Society of Natural Sciences.

The survey of home recreation reveals, among other things, play rooms in 15.6 per cent of the homes, home play evenings in 57.5 per cent and an average of 1.7 children's parties per home per year. Plans and specifications for building home play equipment are included, also directions for the organization and conduct of an educational campaign to promote home play.

The survey represents a practical plan which any community can follow in analyzing its recreation needs. It has many suggestions of interest to the city official, recreation leader, social worker, parent and thoughful citizen. The Buffalo City Planning Association, Inc., may be addressed at 110 Delaware Ave., Buffalo, N. Y.

GENERAL HIGHWAY MAINTENANCE PROBLEMS IN INDIANA

By A. H. Hinkle, Superintendent of Maintenance, State Highway Commission, State House, Indianapolis

(Paper read before 1926 meeting of American Association of State Highway Officials, November 11th, at Pinehurst, N. C.)

I will discuss here a few miscellaneous

problems which may be of interest to some of the delegates.

How Indiana Changed Road Numbers in the Field on Its State Highway System in Ten Hours

I recall at some of the meetings held for selecting the U. S. Highway System that objections were offered because it would require the States to change their highway numbers. I thought perhaps a brief statement of how we changed the numbers of all the state highways in Indiana, might be of interest to you for we found it neither difficult nor embarrassing to make these changes.

Assigning new numbers to Indiana State Highways was necessary, first, in order to conform with the U. S. Highway System and, second, in order to harmonize with the thousand miles of additional roads the Commission is taking into the State system. Although it would not have been necessary to have changed all the numbers, this was done in order to conform with a definite scheme of numbering which the Commission desired adopted.

In order to produce the least confusion to the traveling public and to avoid complications in our bookkeeping system, records, and reports, this change was brought about in the following manner:

Odd numbers were selected for north and south roads and even numbers for east and west roads, to conform with the Federal System of numbering so far as it was practical.

A new map was prepared and printed and copies were available for distribution about the time the change of numbers was made in the field. A newspaper story explaining the change was released a day or two preceding the change.

All numbers were changed in the field on the entire state system in a single day. This change in a single day was accomplished by printing numbers on yellow jute paper. These were tacked or pasted over the old numbers. Printed numbers were sent to each of thirty-two superintendents and they in turn redistributed them among enough men so that no man had more than 25 miles of road on which to change the numbers. Inasmuch as our fiscal year ends September 30th, the change was made on this day so that with the new fiscal year all numbers would be changed and the records and reports made by the field men were likewise made to conform with the new numbers beginning with October 1st. For one month after the change was made the field men were required to put the old number and section letter on all their records and reports and then cross out same and place above it the new road and section letter. This method was required in order to be sure that the field men recognized the new numbering system on their invoices, payrolls, records and reports.

It will take several weeks or perhaps a month or more to erect our more permanent markers which are embossed metal. Inasmuch as the change was made all over the State, our field men can take sufficient time to properly display these metal markers and thus avoid errors and mistakes which naturally result in attempting to erect these in a hurry with inexperienced help.

We found very little confusion either to the general public or our records in making this change. The transition from the old to the new numbers will be recorded in our annual report, leaving a permanent record of the changes made.

Repairing Concrete Roads With Quick Hardening Concrete

An innovation has taken place in the repair of concrete roads from Quick Hardening Concrete. The first method of doing this was with the use of Lumnite Cement. The second improvement developed about two years ago, was in the use of a special mix of the ordinary Portland Cement thus making a concrete which could be opened to traffic after two day's placement. This special mix depended for its quick hardening properties as per method described, I think last year at this Convention, upon the following six factors:

1. Rich Mix.
2. Coarse sand and well graded aggregate.
3. A dry mix.
4. Longer time in mixing.
5. High atmospheric temperature.
6. Use of CaC-12.

This second method is considerably cheaper than the Lumnite Cement mixture.

A third and still greater improvement in making Quick Hardening Concrete is the use of a quick hardening Portland Cement which is now put on the market by at least two cement companies. It has such quick hardening properties that a concrete pavement of the standard mix can be opened to traffic in seven to ten days. This is ordinary Portland Cement made by special refinement processes. It is found by using the special formla described in the second method above, that a concrete patch can be made during hot

weather that can be opened to traffic after one day's placement. In other words, by the use of this Quick Hardening Cement all the advantages of Lumnite cement can be had at a cost far below the cost of concrete made of the Lumnite cement. So far as I am able to conclude, the making of this improved brand of cement of the ordinary Portland type reduces, if not entirely eliminates, the advantages of the Lumnite cement in patching concrete roads.

Stone Quarrying Operations Affect Quality of Stone

This past year we built a penetration macadam road using stone from a local quarry. Although tests made by our Laboratory on the stone indicated it was high quality, we were greatly embarrassed by finding that the stone crushed up badly under the roller. In fact, so badly that it was difficult to do the necessary rolling before the application of the bituminous material necessary to guarantee a good surface.

As work progressed it was finally observed that stone secured later from this quarry offered a much greater resistance under the roller than that at first produced. We made as much of a study as we could conveniently, as to why the difference when the stone was apparently just the same and came from the same ledge. It was finally concluded that the bad results secured at first were likely due to the method of quarrying wherein an excess, or improper grade, of powder had been used in blasting, thus shattering the stone, which later crushed badly under the roller. When careful and normal methods of blasting were developed the stone began to show improved results.

I think without doubt our field men discovered the cause of the trouble. While the effects of improper blasting are more or less known among the quarrying profession, their study has been made more from the point of view of output than of the effects on the stone. This subject might be a fruitful one for some research work on the part of stone producers.

Pulverizing Rock Asphalt with a Threshing Machine; Dragging Rock Asphalt

We have built only a very limited amount of rock asphalt road surface on the State System in Indiana. However, our limited experience developed two features which may be of benefit to others.

1. The cold weather late in the season made it almost impossible to properly rake the rock asphalt because of its lumpy condition. One of our contractors conceived the idea of pulverizing the rock asphalt by passing it through an old threshing machine. The cylinder and concave of this machine were properly mounted in a box about 5-ft. high and a small engine secured for power.

The asphalt was shoveled into the machine much in the same manner as grain is threshed. This broke up the hard lumps into a fine powder, after which the rock could be readily raked, even easier than it could be raked during warm weather.

2. A refinement in securing a smooth rock asphalt surface was developed by dragging it with a heavy metal drag. After the rock asphalt was laid, raked and gone over once with the roller it was leveled off by pulling this heavy metal planer or drag over the surface in practically the same manner as a gravel road is dragged. This planer shaved off the high places and deposited the rock asphalt thus cut off, into the low places. Where there was not sufficient loose material secured by the cutting, a few shovels of additional asphalt were dropped in front of the drag blades from time to time. After this dragging was thoroughly done, the asphalt was again rolled and an almost perfect surface secured.

We experienced a good deal of trouble in securing a smooth riding road on this type of surface, but this process of smoothing which costs very little, seems to solve this problem.

Liquid Asphalts for Treating Gravel and Dusty Stone Roads

For several years it has been common knowledge that a light grade of tar could be used advantageously in treating gravel roads, thus securing a dustless surface. This surface properly made will carry traffic without breaking up during the summer season and frequently the surface would last through the winter and spring with only a limited amount of failures. However, we had no suitable asphalt that could be satisfactorily used on gravel roads until this past season.

We experimented with liquid asphalts made by dissolving ordinary asphalt used in penetration work of about 80 to 95 penetration in suitable distillate, thus producing a form of so-called cut-back asphalt. Experiments this past summer showed that results secured in using this grade of asphalt on gravel compare very favorably with the results secured by the light tar treatment, and that this grade

of asphalt may be even used on a dirty, dusty road with very promising results.

While our experiments along this line are comparatively new, there is every indication that we are approaching a more satisfactory solution of the treating of the dusty roads with bituminous material than has ever been reached before.

SURFACE TREATMENT BY HOT APPLICATION METHOD

By N. S. Anderson, Maintenance Engineer, South Carolina Highway Department

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., November 8-12, 1926.)

Purpose

During the summer of 1923 the South Carolina State Highway Department undertook to develop a bituminous penetration or surface treatment for use on the better class earth type roads of the State Highway System that would promote the comfort of highway traffic during adverse weather conditions and do away with the dust nuisance, as well as enable these roads to stand, without excessive maintenance cost, a comparatively dense motor vehicle traffic until such time as funds might become available to pave them.

Development of Type

Experimental work in connection with the development of such a type of treatment was initiated by Chas. H. Moorefield, State Highway Engineer, in September of that year, by the construction of six short sections varying in length from 100 to 235 ft., on State Highway 2 between New Brookland and Cayce; the work being done under the immediate supervision of Ambrose Harwell, then Maintenance Engineer. Crushed granite was used on all sections and five of them were of a penetration or semi-penetration type varying in thickness from 4½ down to 2½ ins. Four of the five received two applications of tar, the first application being a light tar applied cold and the second a heavy tar applied hot, the fifth section being given only an application of heavy tar applied hot.

The sixth section was of the true surface treatment type being only approximately ¾-in. in thickness, treatment being as follows:

After the original road surface has been swept clean, ¼ gal. per sq. yd. of light tar (Specification No. 1, see appendix) was applied cold and allowed to stand 24 hours with no traffic; 1/3 gal. per sq. yd. of heavy tar (Specification No. 4) was then applied hot and immediately covered with about 45 lbs. per sq. yd. of crushed granite graded from 1¼ to ¼ in. and the road rolled with a 3-wheeled 10-ton power roller before it was thrown open to traffic.

All six sections were closely observed under traffic (which averaged in the neighborhood of 1,500 vehicles per 24 hours) for two months and by that time there were some signs of "pushing" in the thicker sections which were not evident in section six. For that reason and the fact that the thicker treatments would under ordinary conditions cost from three to five times as much, it was decided to extend the thin treatment used on section six and during November, 1923, an additional two mile stretch was constructed.

The original earth surfacing material on this road that was treated in 1923 was decidedly variable, some stretches of it being a sand-clay mixture of rather good quality and others a mixture of sand, clay, gravel and waste from fertilizer factories in various proportions, those containing a large proportion of such wastes being of reddish tinge due to the high content of iron compounds. By the spring of 1924 enough failures had developed in the thin surface treatment over weak spots in the original surfacing to make it very evident that the success or failure of this type of treatment was largely dependent on the quality and supporting strength of the earth road surface so treated and this was kept in mind when two additional roads were picked for treatment during 1924.

The first one of these to be treated was a seven mile section of Route 19 between Spartanburg and Inman, which bears a traffic of about 1,100 vehicles per 24 hours, the subgrade being mostly clay or a sand-clay mixture rich in clay and the surfacing, top-soil of unusually good quality. (For those unfamiliar with our local conditions and nomenclature it should be added that what we designate as top-soil is typically a very small sized gravel with a sand-clay mixture as binder. It occurs chiefly on hills and knolls where the sand-clay soil, which is rich in clay, has weathered enough, usually with the aid of cultivation, so that the excess clay has been washed out, leaving a mixture 4 to 12 ins. in depth over the fields, which gives satisfactory results as road surfacing material except during prolonged dry spells.) This work was done during May, 1924, and was of two different types, one being practically

the same as the thin treatment given section six on Route 2 between New Brookland and Cayce in 1923, namely ¼ gal. per sq. yd. of light tar (Specification No. 1), 1/3 to ½ gal. per sq. yd. of heavy tar (Specification No. 4) covered with about 50 lbs. per sq. yd. of crushed granite graded from 1¼ to ¼ in. and rolled, both tars being heated. The second type was the same, except that "liquid asphalt," a heavy asphaltic oil (Specification No. 9), was used in place of the heavy tar, being applied hot. In order to make both of these types more nearly impervious to water before winter conditions took effect, they were given a locally called "seal coat" during November, 1924. In connection with the first type this consisted of about 1/5 gal. per sq. yd. of light tar (Specification No. 1) applied warm and covered with coarse local sand. The seal coat given the second type consisted of about 1/5 gal. per sq. yd. of a lighter grade "liquid asphalt" or asphaltic oil (Specification No. 6 approximately) than the previous coat, applied warm and covered with coarse local sand. Both of these types have stood up well so far and no further applications of bituminous materials have been made (other than that used in small patches) up to November, 1926.

The second road to be surface treated during 1924 was a 7 1/3 mile stretch of Route 8 between Gaffney and Blacksburg which bears a traffic of about 1,000 vehicles per 24 hours. Here the subgrade was also mostly clay or a sand-clay mixture rich in clay but the surfacing was largely "clay-bound" macadam, consisting of crushed stone bound with clay or a sand-clay mixture rich in clay. Six different surface treatments were given the various sections beginning at Gaffney as follows:

All bituminous material being heated, although this was not absolutely necessary for the prime coats, and all single treatments and second coats of double treatments being covered with crushed stone and rolled.

No. 1. ¼ gal. per sq. yd. of light tar (Specification No. 2), approximately 45/100 gal. per sq. yd. of heavy tar (Specification No. 4).

No. 2. ¼ gal. per sq. yd. of light as- (Specification No. 2), approximately 45/100 gal. per sq. yd. of "liquid asphalt" or heavy asphaltic oil (Specification No. 10).

No. 3. ½ gal. per sq. yd. of "liquid asphalt" or heavy asphaltic oil of same grade as used in No. 2.

No. 4. Approximately 45/100 gal. per sq. yd. of heavy tar of same grade as used in No. 1.

No. 5. ½gal. per sq. yd. of light asphaltic oil (Specification No. 5 approx.), approximately 45/100 gal. of "liquid asphalt" (Specification No. 9), a silghtly lighter grade of heavy asphaltic oil than used in Nos. 2 and 3.

No. 6. ½ gal. per sq. yd. of "liquid asphalt" same grade of heavy asphaltic oil as used in No. 5.

During August, 1925, it became necessary to scarify and retreat about 18 per cent of No. 1, the double tar section adjacent to the city limits, which was probably due to adverse conditions connected with the old surfacing and traffic rather than to the surface treatment itself; about 3 per cent of No. 2, the tar-asphalt section; about 52 per cent of the combined length of Nos. 3 and 6, the single asphalt section; about 60 per cent of No. 4, the single tar section; and about 33 per cent of No. 5, the double asphalt section; all of this retreatment being tar prime, asphalt second coat, covered with crushed stone. During January, 1926, all six sections were given a "seal coat" of 1/5 gal. per sq. yd. of a fairly light "liquid asphalt" or asphaltic oil (Specification No. 7) applied warm and covered with coarse local sand and no further applications of bituminous materials have been made (except that used in small patches) up to November, 1926.

In June and July of 1925 the S. C. State Highway Department in conjunction with the Bureau of Public Roads of the U. S. Department of Agriculture constructed eleven sections of different experimental surface treatment of top-soil roads totaling approximately 15 miles in length, six of the experiments being on Route 15 between Anderson and Clemson College and five on Route 19 between Inman and the North Carolina State line. The costs of construction and of maintenance have been kept separately for each section and the results obtained so far have been both interesting and of very considerable value to the S. C. State Highway Department. The reason that they are not discussed further in this paper is because it is understood that the Bureau of Public Roads will soon issue a preliminary report on this joint experimental work.

During the summer of 1925 it was decided to surface treat an additional 6¾ mile stretch of Route 19, a top-soil road, between Inman and the North Carolina line, and also 7 miles of Route 2, another top-soil road, between Greenville and

Fountain Inn. By this time it seemed evident that although both types of surface treatment given Route 19 during May, 1924, were holding up well, the second type, in which asphalt was used in place of heavy tar for the second coat, was retaining its "life" somewhat better than the double tar treatment. Also Sections 3, 4 and 6 on Route 8 the single treatments of asphalt, tar and asphalt respectively given October, 1924, had not only developed a larger proportion of failures than the adjacent double treatment but also showed in a few places a slight tendncy to "push."

Bearing these results and the comparative prices of bituminous materials in this particular part of the country in mind the type of treatment decided on for this additional 1925 mileage was tar prime coat, asphaltic second coat and asphaltic "seal coat" and with a few experimental exceptions this same type has been used on the approximately 70 miles of surface treatment placed during 1926, the construction work being handled as follows:

Construction

A few months before work is to be started on the surface treatment proper, the old top-soil surfacing on the road is scarified, the necessary additional top-soil added and the road then shaped to the proper crown with road machines and opened to traffic so as to compact the loosened top-soil. It seems always to be a moot point as to just when this scarifying should be done. If it is done too long before the surface treatment, the road, although receiving the ordinary maintenance attention, is likely to get somewhat rough in the meantime; while on the other hand, if traffic is not given time enough to thoroughly compact the scarified top-soil, failures in the surface treatment over the soft spots will result. It is believed to be decidedly preferable to scarify and add top-soil several months before the surface treatment so that the top-soil will have a chance to compact during a number of wet spells and then to scarify very lightly or machine very heavily a comparatively short time before the surface treatment so as to avoid perpetuating corrugations or other rough spots, it being understood of course that during all of this time the usual continuous maintenance work is carried on.

The top-soil surfacing is then swept with a revolving broom pulled behind a truck, and any loose material that still remains in place is removed with hand brooms. The tar prime coat (Specification No. 1) is then applied usually at a temperature of around 125° F. and at a rate of from ¼ to 1/3 gal. per sq. yd., which is as much as the top-soil will absorb readily in one application. The road is ordinarily closed to traffic and the prime coat allowed to dry out for about 24 hours in warm dry weather and a correspondingly longer time in cold or damp weather. (If it is impossibie to keep traffic off the prime coat enough sand is spread over it to keep it from "picking up" and any loose sand remaining is swept off just before the second coat is applied.) It is of course impracticable to avoid having an occasional pot hole or rut in the top-soil surfacing and after the prime coat has been applied, these are filled with crushed stone, which seems to take care of them in a fairly satisfactory manner.

The second coat, which is of "liquid asphalt," a heavy asphalt oil (Specification No. 10 in 1925 and No. 11 in 1926) is then applied at a temperature of around 300° F. and at a rate of approximately 1/3 gal. per sq. yd. and this is immediately covered with about 50 lbs. per sq. yd. of crushed granite graded from 1¼ down to ¼ in. which has been previously deposited in piles along the shoulders of the road and is spread by hand with shovels (scoops). In order to obtain a more even distribution two men usually follow the shovelers and level off the high spots with rattan or wire push brooms and they are followed immediately by a three-wheeled power roller. A 10-ton roller was used originally and, although it would probably be satisfactory for use with a less friable stone, it was found to crush the larger pieces of our granite somewhat more than we desired and the weights of the rollers now being used are from five to six tons.

After rolling, the treatment has the appearance of a crushed granite surfacing with but few signs of bituminous material showing on the surface. It is opened to traffic at once and as time goes on a small part of the crushed granite is "whipped" to the sides, the asphalt works up through the remainder and the treatment consequently becomes darker in color. After the lapse of several months and nearly always before the next winter, a "seal coat" is applied to make it more nearly impervious to water. This consists of "liquid asphalt," a fairly light asphaltic oil (Specification No. 6 approximately in 1925 and No. 7 in 1926) applied at a temperature of around 175° F.,

or higher if the flash point permits, at a rate of approximately 1/5 gal. per sq. yd. and immediately covered with about 15 lbs. per sq. yd. of coarse sand.

We have also used a small amount of a "cut-back" product (Specification No. 8) similar to the old OC-2 described in the Department of Agriculture's Bulletin No. 691. This did not bleed over as long a period as the other nor get as slippery in wet weather. On the other hand it costs more in our locality and we have not been able to "work in" nearly as high a proportion of sand, which results in a much thinner seal coat. Under our present practice nearly all of the wear on the surface treatment is taken care of by the "seal coat," making any decided reduction in thickness seem uneconomical and, consequently, our use of the cut-back material has been rather restricted.

The amounts of materials used on, and the cost of construction of, three typical jobs are as follows:

Route 2, Greenville-Fountain Inn, 10.83 miles treated for width of 18 ft. in 1925. Tar prime 0.292 gal., asphaltic second coat 0.358 gal. and crushed stone 50.4 lbs. per sq. yd. at a cost of $1,885 per mile. "Seal Coat" at cost of $202 per mile.

Route 8, Cowpens-Gaffney, 6.93 miles treated for width of 20 ft. in 1926. Tar prime 0.300 gal., asphaltic second coat 0.352 gal. and crushed stone 54.1 lbs. per sq. yd. at a cost of $1,846 per mile. No "seal coat" placed up to October 10, 1926.

Route 8, Anderson-Greenville, 28.2 miles treated for width of 20 ft. in 1926. Tar prime 0.263 gal., asphaltic second coat 0.376 gal. and crushed stone 54.2 lbs. per sq. yd. at a cost of $2,060 per mile. No "seal coat" placed up to October 10, 1926.

It is to be noted that the above costs do not include cost, interest charges or depreciation of heavy equipment such as trucks, rollers and distributors nor cost of the engineering supervision given the work by the Division and Headquarters offices. Also that the cost of the preliminary work of putting the top-soil surfacing in first-class condition is not included. Nearly all the sand used in the "seal coat" on the first of these three jobs was taken from the side ditches, which accounts for its low cost. Ordinarily the sand is hauled from nearby creek beds and dumped in piles along the shoulders of the road and in such cases the same type of "seal coat" costs very close to $300 per mile.

Maintenance

For a week or so after the completion of the surface treatment, exclusive of the "seal coat," a power roller is of considerable value in the maintenance work, during hot weather particularly. In cases of partial failures due to poorly compacted top-soil, if sufficient moisture is present in the soil it can sometimes be compacted and the broken surface treatment rebounded by rolling, without the use of additional materials. However, after the surface treatment has "set up," we make no further use of the rollers, the maintenance equipment consisting of trucks, trailer type portable heating kettles equipped with hand pump, hose and spray nozzle and the necessary small tools, including tamps. Pot holes, caused usually by sand pockets or an excessive amount of clay and mica in the top-soil, as well as narrow strip failures due to a nozzle on the distributor having become blocked during the application of the second coat, are patched promptly as they occur. Both "liquid asphalt," a heavy asphaltic oil of the same specification as that used in the second coat, and cold patch are used. Enough crushed stone for use with the former for a considerable length of time is available from the excess "whipped" to the side of the surface treatment. Crushed stone of a somewhat smaller maximum size than that in the original treatment, is shipped to convenient points where it is mixed with the cold patch and the mixture stored until it is taken out to the road on trucks. The patching done in place with the heavy asphaltic oil is somewhat the cheaper but has the disadvantage that the tendency of the average workman, particularly of a "green" one, to use altogether too much bituminous material, results in patches that are thicker than the adjacent surface treatment, which of course produces irregularities in the road surface.

Under traffic, the surface treatment, particularly if the original treatment was narrow, constantly tends to lose width by failure of the outer edges. We have tried to obviate this by thickening the edges during construction and to control it during maintenance by not only thickened edges but also by the use of both cold patch mixture and crushed stone bound with asphalt of 85 to 100 penetration. The results obtained so far seem somewhat promising but not very decisive.

The maintenance costs of our first surface treatment of a top-soil road, the seven mile stretch on Route 19 between Spartanburg and Inman previously mentioned, have not been kept separately

for the two types of treatment but are rather interesting nevertheless. The "seal coat" cost $304 per mile and the first year's maintenance cost exclusive of the seal, amounted to $385 per mile. The second year's maintenance cost was $258 per mile and its present condition indicates that the cost during the third year will probably not exceed $300 per mile. These costs include work on the shoulders, ditches and culverts, etc., but do not include depreciation of equipment or cost of supervision by the Division or Headquarters offices and are for a route that would cost at least $600 per year to maintain properly as an untreated top-soil road.

The first year's maintenance cost of the 10.83 mile stretch on Route 2 between Greenville and Fountain Inn completed in 1925 amounted to $451 per mile exclusive of the $202 per mile "seal coat." This is about in line with the above, considering the fact that the treatment was some 2 ft. wider than on the older road and the quality of top-soil inferior.

Value and Adaptability

Although our experience with this type of surface treatment has been comparatively short-lived, we have reached some rather tentative conclusions, chief among which are the following:

First, that this particular treatment is absolutely unsuited for use on such of our roads as have a poor quality of sand-clay or other earth surfacing that has not sufficient inherent supporting strength to prevent deformation under the usual wheel loads of highway traffic.

Second, that the treatment is suitable and economical for use on those of our roads having a good quality of top-soil surfacing and carrying a fairly dense traffic largely of motor vehicles of which only a small proportion are heavily loaded trucks, and under these particular conditions, makes at least a valuable "stop gap" until funds become available for paving.

For instance, take the seven mile stretch on Route 19 between Spartanburg and Inman that was completed early in the summer of 1924. The preparation of the top-soil surfacing cost less than $200 per mile, the original surface treatment not over $2,000 and the "seal coat" $304 per mile, the first year's maintenance $385 and the second year's maintenance $258 per mile. Thus the construction plus the maintenance cost divided over the two year period amounts to about $1,573 1/3 dollars per mile per year. The present condition of the road indicates that the third year's maintenance cost should not run over $300 per mile which would give a construction plus maintenance cost over a three year period of $1,149 per mile per year; and even if it should become necessary to place the second "seal coat" before the expiration of the third year, this cost would be increased to only about $1,249. The construction costs of the work being done this year do not run much higher than those given above. The Anderson-Greenville road, a long haul job, cost about $209 per mile more for the preliminary work and $60 per mile more for the original surface treatment, a total increase of $269. The Cowpens-Gaffney road, on which an unusually large number of curves were banked, cost $729 more per mile for preliminary work and $154 less per mile for original surface treatment, a net total increase of $575. The cost of the "seal coat" on these two roads should not be more than the $304 mentioned, and we have no reasons to anticipate that the maintenance costs will be very much higher. In the case of the Spartanburg-Inman job we have given the traveling public a road with excessive crown (the crown of the old top-soil surface was not materially reduced), unbanked curves, considerably rougher riding than pavement but altogether smoother than the average condition in which top-soil surfacing can be maintained within a reasonable cost, and which is dustless and not affected by adverse weather conditions. In the other two cases, the crown has been suitably reduced, the curves banked and the roads are not only dustless and unaffected by adverse weather conditions but also nearly as comfortable to ride over as the average pavement.

These construction plus maintenance costs just given do not include cost, interest charges or depreciation of heavy equipment nor cost of engineering supervision given by the Division and Headquarters offices. However, if you will go ahead and add any amount in reason to cover this omission and then compare your figures with the interest charges on the construction cost plus the cost of maintenance of the usual types of high class pavement (say 5% on $25,000 plus at least $150 per mile for maintenance of shoulders and ditches, etc., a total of $1,400 per mile per year) I believe that you will agree with me in concluding that our surface treatment of existing top-soil roads has enabled the South Carolina State Highway Department to give its

Appendix

Specifications of Bituminous Materials Used

LIGHT TARS

No. 1 The tar shall conform to the following requirements:
- (a) Water, not more than 2.00 per cent.
- (b) Specific viscosity, Engler, 50 cc. at 40° C. (104° F.) 8 to 13.
- (c) Distillation test on water-free material:
  - Total distillate, by weight, 0 to 170° C. (32 to 338° F.), not more than 7.00 per cent.
  - Total distillate, by weight, 0 to 235° C. (32 to 455° F.), not more than 20.00 per cent.
  - Total distillate, by weight 0 to 270° C. (32 to 518° F.), not more than 30.00 per cent.
  - Total distillate, by weight, 0 to 300° C. (32 to 572° F.), not more than 35.00 per cent.
- (d) Specific gravity at 25/25° C. (77/77° F.) of total distillate to 300° C. (572° F.), not less than 1.01.
- (e) Softening point (Ring-and-Ball Method) of residue from distillation test, not more than 60° C (140° F.).
- (f) Total Bitumen (Soluble in Carbon Disulphide), 88 to 97 per cent.

No. 2 Same as No. 1 except:
Specific viscosity, Engler, 50 cc. at 40° C. (104° F.) 11 to 16.

No. 3 Same as No. 1 except:
Specific viscosity, Engler, 50 cc. at 40° C. (104° F.) 18 to 25.

HEAVY TAR

No. 4 The tar shall conform to the following requirements:
- (a) Water, 0.00 per cent.
- (b) Float test at 32° C. (89.6° F.), 150 to 210 sec.
- (c) Distillation test:
  - Total distillate, by weight, 0 to 170° C (32 to 338° F), not more than 1.00 per cent.
  - Total distillate, by weight, 0 to 235° C. (32 to 455° F.), not more than 10.00 per cent.
  - Total distillate, by weight, 0 to 270° C. (32 to 518° F.), not more than 15.00 per cent.
  - Total distillate, by weight, 0 to 300° C. (32 to 572° F.), not more than 25.00 per cent.
  - Residue, by weight, not less than 75.00 per cent.
- (d) Specific gravity at 25° C. (77° F.) of total distillate to 300° C. (572° F.), not less than 1.03.
- (e) Softening point (Ring-and-Ball Method) of residue from distillation test, not more than 65° C. (149° F.).
- (f) Total Bitumen (Soluble in Carbon Disulphide) 78 to 95 per cent.

LIGHT ASPHALTIC OILS ("Liquid Asphalts")

		Min.	Max.
No. 5	Specific Gravity at 60° F.	.93	.96
	Weight per gal. at 60° F., lbs.	7.83	
	Saybolt Viscosity at 130° F.	350	400
	Specific Engler Viscosity at 122° F.	6	10
	Flash (Open Cup) F°	220	
	Volatility, 50 Gr., 5 hrs., 325° F., per cent		18
	Asphalt, 50 Gr., 5 hrs., 325° F., per cent	45	50
	Solubility in Carbon Bi-Sulphide, per cent	99.8	
No. 6	Specific Gravity at 60° F.	.935	.965
	Beaume Gravity 60° F.	16	19
	Weight per gal. at 60° F., lbs.	7.85	
	Penetration 77° F. 100 gr. 5 sec.	too soft	
	Viscosity Saybolt	400	500
	Viscosity Engler (Specific)	2.4	3.0
	Flash point (Open Cup) °F.	200	
	Volatility 20 gr. 5 h. 325° F.		16%
	Asphalt 100 pen. at 500° F., per cent	55	
	Soluble in Carbon-disulphide, per cent	99.8	

No. 7 This material shall have the following characteristics:
- (a) It shall be free from water.
- (b) The various hydrocarbons composing it shall be present in a homogeneous solution.
- (c) It shall have a specific gravity at 60° F. of not less than 0.935.
- (d) Viscosity Engler Specific, 212° F., 2.4 to 4.4.
- (e) Flash, Open Cup, F°., not less than 200.
- (f) It shall have an oven evaporation at 325° F. of not more than 16 per cent.
- (g) When evaporated in the open air at a temperature not exceeding 500° F. until the residue remaining has a penetration (77° F., 100 g., 5 sec.) of 100, the amount of such residue shall not be less than 60 per cent of the original oil. The ductility at 77° F. of this residue shall be not less than 25 cm. (Dow mold).
- (h) Its solubility at air temperature in carbon disulphide shall be at least 99.5 per cent.

No. 8 The road oil shall be homogeneous, free from water. It shall meet the following requirements:
- (a) Specific gravity 25/25° C. (77/77° F.), 0.935 to 0.970.
- (b) Flash point, not more than 50° C. (122° F.).
- (c) Specific viscosity at 25° C. (77° F.), 80 to 120.
- (d) Loss at 163° C. (325° F.) 5 hours, not more than 30 per cent.
- (e) Total bitumen (soluble in carbon disulphide), not less than 99.5 per cent.
- (f) Per cent of total bitumen insoluble in 86° B. naphtha, not less than 6.0 per cent.

HEAVY ASPHALTIC OILS ("Liquid Asphalts")

		Min.	Max.
No. 9	Specific Gravity at 60° F.	1.0	1.02
	Beaume Gravity at 60° F.		
	Weight per gal., 60° F., lbs.	8.38	
	Penetration, 77° F., 100 gr., 5 sec.		
	Viscosity, Saybolt (Temp.)	1700 (212° F)	2300
	Viscosity, Engler, Specific (Temp.)	47 (212° F)	66
	Flash, Open Cup, F°	365	
	Volatility, 50 gr., 5 hrs., 325° F., per cent.		4.0
	Asphalt 100 pen. at 500° F., per cent.	80	
	Solubility, Carbon Bi-Sulphide, per cent.	99.8	
No. 10	Specific Gravity at 66° F.	1.01	1.03
	Beaume Gravity at 60° F.		
	Weight per gal., 60° F., lbs.	8.46	
	Viscosity, Saybolt (Temp.)	2300 (212° F)	3500
	Viscosity, Engler, Specific (Temp.)	65 (212° F)	75
	Flash, Open Cup, F°	365	
	Volatility, 50 gr., 5 hrs., 325° F., per cent.		3
	Asphalt 100 pen. at 500° F., per cent.	82	
	Solubility, Carbon Bi-Sulphide, per cent.	99.8	

No. 11 The asphalt shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).

Physical and chemical properties.

It shall meet the following requirements:

(a) Specific gravity 25/25° C. (77/77° F.) not less than 1.00.
(b) Flash point not less than 175° C. (347° F.).
(c) Penetration at 25° C. (77° F.) 100 gr., 5 secs., 150 to 200.
(d) Loss at 163° C. (325° F.) 50 grs., 5 hours, not more than 2.0 per cent. Penetration of residue at 25° C. (77° F.) 100 g., 5 sec., as compared to penetration before heating, not less than 60 per cent.
(e) Bitumen (soluble in carbon disulphide) not less than 99.5 per cent. Organic matter insoluble, not more than 0.2 per cent.

traveling public a much larger mileage of comfortably riding roads than would otherwise have been possible; that during a period of three or four years, the cost of construction plus maintenance of the surface treatment should not exceed the interest charges on construction cost plus maintenance cost of a high class type paving; that the resulting three or four years extension of life of the paving should at least take care of any anticipated increase in its construction cost due to the postponement; and that it is well worth while for other localities, who may have similar conditions to meet, to investigate and experiment with this and other types of surface treatment.

ECONOMY OF SNOW REMOVAL FROM HIGHWAYS

By W. A. Van Duzer, Deputy Engineering Executive, Pennsylvania Department of Highways, Harrisburg, Pa.

(Presented at Annual Meeting of American Association of State Highway Officials, Pinehurst, N. C., November, 1926.)

Maintaining traffic during the winter months is becoming one of the most important functions of a maintenance organization.

The organization of snow removal forces is very similar throughout the country; the starting of the men, actually removing the snow, the supervisor in charge, the district supervisor in charge of county or other unit, and finally the headquarters' directing head, to whom conditions are reported so that information can be given to the newspapers and the traveling public.

Equipment, by this I mean plows, trucks, tractors and snow fence, must be balanced. From past experience with drifting conditions, it is possible for the local supervisors to designate sections where snow fence would be required, and under normal conditions trucks with "V" and moldboard types will expeditiously remove the snow.

Drift prevention adds materially to the reduction in cost of snow removal work, but it is necessary, in order to meet emergencies, to have large equipment such as tractors equipped with either "V" type or rotary type plows, available for transfer to points where a shifting wind has caused drifting or where lack of sufficient snow fence has caused a depth of snow that cannot be removed by the ordinary truck plow.

From the highway engineers' standpoint, snow removal is the means of avoiding partial loss of the investment value in road improvements and of reducing maintenance costs.

If a road is blocked, the investment is idle and the interest value is being lost. If snow drifts are allowed to remain on the road, when traffic does break through it will follow the line of least resistance and will travel in ruts, weaving from side to side and out on the shoulders at intervals; when the snow melts the shoulders will suffer, and if the pavement is a flexible type, it will be seriously damaged.

The Pennsylvania primary system rep-

resents an investment of about $150,000,000, which at five per cent is worth $625,000 per month, or if service is considered, winter traffic being approximately one-half of the annual average, it is worth $312,500 for a winter month. Unremoved snow would block the roads about two months with a loss of $625,000 of interest value alone. I believe snow removal saves us at least that much, additionally, in reducing repairs and depreciation. Snow removal in Pennsylvania saves about one-half as much as we believe it is worth.

The traveling public's interest in snow removal is to be considered. Just as there must be a constant relation between production and consumption, so there must be an equal balance between providing transportation facilities and their use, and the value of the roads to the traveling public should at least equal the physical valuation.

Approximately one-half of all of the car miles of travel in the state of Pennsylvania are on our primary system. Therefore, the blockade of the primary system would mean a 50 per cent loss of interest value in the motor vehicles registered in the state. The total registered is approximately a million and a half, representing something like one billion dollars of investment and five million dollars interest value per month. Two and one-half million dollars then would be the total interest value for a winter month and one and one-fourth million dollars the interest value to set against a month's use of the primary system in winter.

We would need to show only one and one-fourth million dollars snow removal value to the traveling public, on the basis of two month's blockade, to check the estimate of corresponding value to the state and the fact that the value to the traveling public is shown to be double the value to the state may be an explanation of the fact that we are urged to increase the snow removal program each year.

Viewing the work of snow removal from the standpoint of economy, there is no doubt that in many cases drift prevention is more economical than snow removal. In a number of cases we have actually been able to eliminate bad winter conditions by relocating sections of road and placing them on wind-swept ridges instead of on side hills. In other cases, we have been able to improve conditions by raising the grade line, widening the cuts and flaring their entrances.

In cases where we were unable to eliminate the objectionable drifting tendencies by relocation or grading, we found that we save money by the use of snow fence.

The most economical type of snow fence appears to be a woven picket and wire hung on driven steel posts. This fence is easily removed and the cost is about one-third of the railroad type of snow fence.

Passing on to equipment, the requirement of economy is accompanied by the proviso that the equipment must be able to handle the work. We find that in general our ordinary tractor and truck equipment, fitted with adjustable plows, will keep our roads open, but in sections where we have the heaviest snow fall a more powerful type is required and used even though its cost is greater. The justification for the greater expenditure is that the roads in this section cannot be kept open continuously except with special equipment.

There is little opportunity for discussion of organization from the standpoint of economy, the advisability of handling the work with the general maintenance organization being so obvious.

We believe that all states that have heavy snow fall and that are doing snow removal work find that providing winter employment for their best maintenance men has simplified their problems of spring reorganization of working forces.

Clearing the pavement its full width does not constitute all of snow removal work. It is necessary to spend more money after clearing the pavement in order to save money when the next storm comes. Snow banks must be moved back to make room for the disposal of additional snow, shoulder drains must be opened at intervals along the road, as well as culverts and side drains, especially when thawing weather comes, to secure the full value of snow removal in reducing spring maintenance costs.

As an added service to the traveling public, it has been the practice for several years in Pennsylvania to place cinders or screenings upon certain sections of pavement that are icy. The cost is very small and it not only receives favorable comment, but from personal experience in driving over these roads, we know that this method has prevented numerous accidents.

CAUSES OF SUCCESS AND FAILURE OF BITUMINOUS MACADAM PAVEMENTS

By George H. Henderson, Chief Engineer, Rhode Island State Board of Public Roads

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., November 8-12, 1926.)

The success or failure of a bituminous macadam depends on the degree of care given the various details entering into the construction of the entire road. Only a few years ago the construction of any hard surfaced pavement in place of a poor country road was considered by the public using the road as successful so long as the integrity of the pavement remained. Very little was heard concerning poor alignment, bad grades or poor riding quality of the pavement. Today, at least in Rhode Island, the motoring public is more discerning and are beginning to take note of the riding quality of the pavement, the alignment and grades.

A few years ago good construction meant the building of a good stable road, while today good construction means the building of a good stable road in good alignment and grade and having almost perfect riding qualities. In order to build successfully a bituminous macadam which when completed will present a neat appearance, which will be stable and whose riding qualities will be excellent, attention must be given to each detail of construction from the bottom to the top.

In Rhode Island, as well as in many other sections of New England, soil conditions vary within very limited areas. It is not uncommon to run out of gravel, into clay or other poor subsoil, and back into gravel within a few hundred feet along the line of construction. Were the subsoil of uniform texture, whether good or poor, the construction of the road in so far as foundations are concerned would be simplified.

Our frost depth varies between 2 and 5 feet. It is conceded by engineers that where frost action abounds extra care must be observed in providing proper drainage and foundations under road pavements. It is not the intention of this paper to expound on theories of drainage and foundation. Suffice to say that in New England where the soil conditions are so variable, if proper foundations and drainage are not provided in sections where poor subsoil exists the integrity of the pavement will be seriously threatened. It also is conceded that a layer of granular material directly beneath the pavement proper serves to break up capillarity and to lesson in a great measure the detrimental effect of frost action.

It is our practice to replace poor subsoil with a uniform layer of gravel or stone foundation, the depth varying with the degree of tightness of the soil. The only rule that we have for determining the proper depth of foundation is the "rule of experience." We have seldom found a case of bad subsoil that a uniform layer of 12 ins. of coarse, permeable gravel would not take care of, provided it is tapped out through the shoulders and properly drained.

Through ledge sections where water seepage may be expected we employ a stone fill of 9 and 12 ins. with subdrains at least on one side of the road and frequent taps from the stone fill into the stone or gravel filled subdrain trench. Through particularly bad muck soil we sometimes have laid a blanket course of sand or fine gravel, usually 4 to 6 ins. in depth, over which we have constructed our standard stone fill, or stone foundation, the object of the blanket course being to hold the muck down and prevent its rising and filling the interstices of foundation above.

We believe that the almost total absence of heaving and breaking up of our macadams laid during the past 13 years is due to the method of treating the subgrade which has been in vogue during the above period.

Considering the integrity of the the pavement and its riding quality, several factors enter into successful construction. Of prime importance, of course, is the preparation of the subbase upon which the base course of crushed stone is to be placed. Whether the subgrade is of natural soil or a subgrade prepared by using gravel, coarse stone or any other granular material, it should be thoroughly compacted and made hard over the entire width of the pavement and preferably for at least 12 ins. outside of the pavement. Any soft spots that are allowed to remain in the subbase will finally work injury to the riding qualities of the pavement.

Soft spots are not always caused by pockets of poor material constituting the subgrade. Often it is a case where the material in the soft pockets, while not bad in itself, is of such different nature or grading from the surrounding material

in comparison. When contractors have been asked to eliminate soft spots in a gravel foundation they sometimes question the wisdom of making a substitution, their argument being that the material is granular and that it came out of the same gravel pit as the rest of the subgrade. They assert that the unevenness can be ironed out in the base course of stone. If it is allowed to remain and is not thoroughly ironed out in the base course of crushed stone, it is taken out in the top course of stone. Our experience teaches us that where these soft spots are allowed to remain in the subbase, even though any unevenness is taken out in either course of stone, it is only a question of time before a depression in the finished pavement will occur at the spot. The little inherent strength in the constructed macadam may bridge the spot for a while, even a year or two, but eventually it will let down.

Another essential in good construction is the placing of sufficient shoulder along the sidelines to hold the crushed stone courses. If care is not given to this detail, insufficient shoulder material may be placed to properly sustain the crushed stone at proper grade during the process of rolling. Where an insufficient amount of shoulder material is placed, the crushed stone during the rolling process pushes out to a greater or less extent, with the result that the outside edges of the finished pavement are uneven in contour or inclined to be scalloped. We have seen cases where the detrimental effect has extended into the pavement for two or more feet, injuring noticeably the riding quality of the pavement along its outside edges. In the event of future widening of the pavement it is necessary to cut back a considerable distance into the metal in order to obtain a standard cross section. In some cases where the widening of the pavement was not involved, traffic so avoided the outer 2 ft. of the pavement because of its uneven riding quality that it was found necessary to rebuild the outer edge in the interests of safety to the traveling public, even though there was not a single break in the pavement.

The construction of the pavement proper calls for considerable care in the details. If the work is being done by a qualified contractor having an organization well versed in bituminous macadams construction, the battle is 90% won. If an inferior contractor is doing the work, even under rigid inspection, it sometimes is difficult to secure a satisfactory job. We have seen bituminous macadams constructed successfully where the mineral aggregate used was not of the best in quality and during periods when construction conditions were not particularly favorable, and we have seen bituminous macadams poorly constructed where the best of materials were used and under most favorable conditions. The word "successful" is intended to cover both the lasting integrity of the pavement and the riding qualities of the same.

In Rhode Island we have four classes of aggregate employed in the construction of the bituminous macadam, namely, crushed local wall or field stone, crushed local ledge, crushed local gravel, and trap rock which is imported from our neighboring state, Connecticut. The French coefficient of wear and toughness of our local stone vary within wide limits. Most of it we believe too soft for use in the wearing course of a bituminous macadam. Occasionally we find local ledges of exceptionally good quality. Where suitable local stone is available and the length of the work involved justifies the setting-up of a crushing plant, we employ local stone in the base course with success. In the wearing course, or penetration course, except in isolated cases we employ trap rock.

With our local stone as crushed on the job we have difficulty in securing uniformity in size and quality. The lack of uniformity in crushed sizes of local stone we believe has little detrimental effect in the construction of the base course, but the same lack of uniformity in sizes we believe has a very definite effect if used in the penetration course. The breaking down of the softer local stone under the roller plugs up the voids, which results in uneven distribution of the binder, causes fat spots, and is in general detrimental to the pavement. We use the harder stone in the penetration course because of its superior wearing quality and especially because of its uniformity in sizes. When laid this stone presents a more uniform distribution of voids for the penetration.

Where local stone is used in the base course most of the run of the crusher up to sizes passing a 3-in. ring are utilized. Where local stone is permitted in the top course the size is limited to stone passing a 3-in. ring and retained on a 1½-in. ring. In trap rock we use in the penetration course stone passing a 2½-in. ring and retained on a 1½-in. ring; for the filler, or key stone, sizes passing a 1-in. ring and retained on a

⅝-in.; and for cover, clean ⅝ to ⅜-in. screenings. We have used a slightly smaller size in the large stone with uniformly good results. The size of the stone specified can be varied somewhat, but it should run uniform in size and show an even distribution of voids when spread, which will permit of an even penetration of the binder to the full depth of the wearing surface. Our standard bituminous macadam calls for a 5½-in. base course and a 2½-in. wearing course. For binder we have used almost exclusively an oil asphalt of 85 to 100 penetration.

With the above materials it is possible to construct a first-class bituminous macadam and all the varying degrees down to a poor bituminous macadam, depending for the most part on care used in the details of construction. As in the case of a uniformly rigid subbase, we believe it essential that the first course of stone after completion should be uniformly hard and true to contour. The penetration course of stone should be uniform in depth to insure the best results. Men experienced in raking stone can secure this uniformity in depth and contour regardless of whether or not mechanical stone spreaders are used. If the stone spreaders are not expert, constant attention must be paid by the engineer in charge to this work or the riding qualities of the finished pavement may be poor.

It is our practice to fill the base course of crushed stone with sand or crusher dust during the rolling process. After the stone is first rolled, the sand is applied in light coats as the stone is rolled, more being added until the bottom course no longer creeps or depresses appreciably under the roller. If heavy trucks are to be used on the base course for a considerable period before the top course goes on, a layer of sand or dust up to an inch in depth is sometimes spread over the bottom course to protect it. Before the top course of stone is spread this excess sand or dust is swept off of the bottom course to expose the stone in the bottom course and to permit a bond with the top stone.

Except in cases where extremely wide shoulders are available for traffic, before spreading the top stone we believe it absolutely essential that the ¾-in. and ½-in. stone, used as key stone covers, respectively, be stacked in small piles along the shoulder of the road. It is poor parctice to allow trucking through the top course of stone.

In the application of the asphaltic binder, considerable finesse is involved. Fortunately, in Rhode Island the asphalt for practically all our jobs can be hauled over the road in pressure distributors from central heating plants belonging to the oil companies. Three-quarters of the area of the State is within 25 miles of these plants. Ordinarily we plan to get a gallon and three-quarters cold to a first application and three-quarters to a gallon cold on the seal coat. Needless to say, an even distribution of the asphalt is essential and also that the asphalt should penetrate the full depth of the stone. This can be obtained only by having the stone clean, by having evenly distributed open voids in the stone, by having the asphalt hot enough, and by having the pressure distributor in perfect condition mechanically. If the asphalt is underheated, it does not get into the stone as it should.

The temperature of the binder can be regulated by thermometer testing better than by guesswork. Our specification calls for the binder to be heated to a temperature between 275 and 350 degs. Fahrenheit. We believe as near 350 degs. as possible is the best practice, especially in cold weather.

The nozzles of the pressure distributor should be tested to see that they are clear before the distributor is used.

In Rhode Island three types of pressure distributors are in general use. On one type pressure on the bars and nozzles is applied by steam generated by a separate boiler attached to the rear of the rear of the truck. With this equipment occasionally the pressure goes down before the full tank load is distributed. On another distributor an auxiliary clutch from the motor is used in obtaining pressure and the pressure obtained is in ratio to the speed of the truck. It is difficult to get high pressure and low speed at the same time. A third outfit has a separate power unit for generating air pressure, which unit has no connection whatsoever with the motor on the truck. With this outfit a uniform pressure can be obtained regardless of the speed of the truck.

Before the first penetration all foreign matter such as leaves, twigs, sticks, etc., which may have blown onto the top stone, should be removed.

The engineer in charge, knowing the volume of binder in the distributor and the width of spread, should figure the distance that should be covered in the distribution and place a stake at this

point as an aid to the driver of the truck. No one but an experienced driver should be allowed on the distributor and he should average within 10 ft. of the mark on each distribution.

Where possible it is preferable to penetrate the left-hand side of the road first as the driver generally sits on the left side of the car and is better able to secure an even line of distribution. On our standard 18-ft. road it is our practice to spread 10 ft. on the first half of the road and 8 ft. on the second half. This system permits the spreading of the key stone and the rolling on the entire half of the road. The penetration must be carried a considerable distance before seal coat is applied, owing of course to the fact that less asphalt is used in the seal coat and a distributor load covers a greater distance. Where the first penetration was for a 10-ft. strip on the left-hand side of the road, a 10-ft. strip on the seal coat is applied on the right-hand side of the road. In this manner of application the seal coat application and the penetration application are staggered.

Streaks in the penetration course of stone should be penetrated with a hand hose and not left for the seal coat to cover up. When the streaks are not taken care of and are covered by the seal coat, raveling often takes place after the seal coat has been applied.

When the asphalt is hot enough and there are skips, it is evident that the nozzles are plugged. Under this condition there is generally present bluish smoke. If the bluish smoke is not present and there is streaking, it generally means that the asphalt is not hot enough and the distributor should be stopped and the asphalt brought to the proper temperature.

Too heavy an application of binder is to be avoided as it may be the direct cause of corrugations which develop after the pavement has been opened to traffic.

After the first application only enough key stone should be spread in order to permit rolling. A strip 8 to 12 ins. wide should be left unfilled until the second half of the road is penetrated. This avoids the spreading of excess key stone along the dividing lines of penetrations and prevents a ridge developing along the center. After the initial rolling enough key stone is added to fill the voids in the top course of stone and the road is then rolled to its final cross-section. Hand pushbrooms or mechanical brooms or brushes of various types are used to spread the key stone evenly over the penetration course. All excess stone over and above that needed to fill the voids is cleaned off before the seal coat is applied. The key stone is not a separate course of stone but only a filler and after it is applied the surface of the pavement should be mosaic in appearance. After the seal coat application the pea stone is spread in sufficient quantity to completely cover the seal coat.

In addition to skillful rolling required in the construction of a good bituminous macadam, it is essential that the pavement secure sufficient rolling to thoroughly compact the stone. We do not believe it possible to overroll a bituminous macadam after the binder has been applied. It is our practice to require the rolling of the top course of stone to a firm set before the first application of the binder and to require the back-rolling for several days after the pavement is completed. This practice demands more durable stone. In cold weather back-rolling is confined to the warmer part of the day—usually between ten o'clock in the morning and two o'clock in the afternoon.

It is our practice to open the road to travel as soon as the seal coat has been covered. Occasionally when expediency demands it we have opened the road to travel after the first penetration was thoroughly rolled. We have experienced no bad results from this practice.

In the above we have sketched briefly our method of building bituminous macadams. We know that other methods vary in detail to a greater or less extent from our method. Doubtless there are many ways of building bituminous macadams: good, fair and indifferent. Probably it is the indifferent methods of building bituminous macadams that have been the direct cause of many failures.

In the construction of a reinforced cement concrete pavement, which has certain inherent strength, we are not prone to slight the details of construction. The question arises, should we slight the details of construction in a bituminous macadam which has little or no inherent strength? Doubtless if the same care were exercised in the use of materials and the construction operations of a bituminous macadam as is used in the construction of a concrete pavement, much better pavements would result and there would be fewer failures.

In conclusion, I would say that a successful bituminous macadam generally follows where the essential details of construction are adhered to, while the

slighting of these essential details of construction often spells failure. Probably the worst disease prevalent in road construction is that known as expediency, and few, if any, of us, are immune from it. Expediency often calls for the use of materials not in accordance with specifications and sometimes calls for the slighting of essential details of construction.

To insure a successful bituminous macadam, begin at the bottom and provide proper foundations and drainage; construct a firm subbase; if there are weak spots in the subbase, remedy them before spreading the first course of stone; if there are uneven spots after the first course of stone is rolled, remedy the trouble before spreading the top course of stone; if spots in the top stone are tight due to an accumulation of small stone or the breaking-down of stone that should not be in the top course, remove them before the first penetration; if after the first penetration there are streaks, take care of them before allowing the seal coat to be applied. In other words, constant care during the whole construction process should be taken and faults corrected as they occur.

The average cost of our bituminous macadams proper, exclusive of drainage, foundations, engineering, etc., has been $17,750 per mile for an average width of 18 ft. The total average cost, including grading, foundation, etc., is approximately $32,000 per mile. Our average maintenance cost of bituminous macadam constructed since 1913 has been approximately $150 per mile per year.

We have one bituminous macadam constructed in 1913 which has yet to see its first seal coat. Several of our bituminous macadams constructed in 1916 were sealcoated for the first time in 1923 after a period of seven years. These bituminous macadams were for the most part constructed on our routes of heaviest travel. As far as we are able to judge, most of these pavements built since 1915 will serve traffic for many years to come.

ECONOMICS OF SALVAGING OLD PAVEMENTS

By R. Keith Compton, Director of Public Works, Richmond, Va.

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., November 8-12, 1926.)

It is assumed that in assigning this subject to the speaker, it was intended to include only those old pavements which may be used as a base and covered with one of the standard bituminous tops or wearing surface. The standard top would include the standard sheet asphalt pavement known as binder and top, asphaltic concrete—both fine and coarse aggregate, including the types known as Bitulithic and Topeka, and also Bessonite, the wearing surface designed sometime ago by Major F. S. Beeson, U. S. A., who was at that time Assistant to the Engineer Commissioner, Washington, D. C.

The economics of this subject can be very intelligently discussed from a practical point of view, but it is a very difficult matter to intelligently discuss them from a financial standpoint. This difficulty is due largely to our governmental methods, both state and municipal, and our tendenecy to have a change of administration every few years, with the result that not only is there a change in the engineering executive, but frequently changes in the personnel of the engineer's office force. This results in either failure to continue systematic cost accounting, or else considerable confusion in the records. A new executive coming into office is fortunate indeed if he can hold in office the subordinates who have been well trained by his predecessor and who are prepared to carry on the same intelligent system of cost accounting as may have been instituted under his predecessor.

Some years ago, urged by many of his colleagues, the speaker sent out a questionnaire on street paving and among the questions propounded was one as to conclusions regarding the life of each type of pavement and foundation. This questionnaire was sent to the responsible engineering head of approximately 750 cities of the United States and Canada, as well as to the State Highway Departments in all the states. Approximately 300 replies were received to the questionnaire. Very few of them made any answer at all to the question regarding life of pavement and foundation, and those replies received, as a rule, were so indefinite and erroneous as to preclude any possibility of their being of value for publication. It is doubtful if there are a dozen municipalities which have accurate and well balanced cost accounting methods on street pavement construction, with reference to replacement and maintenance.

The point the speaker is coming to is this: In every highway engineer's budget, be his position either municipal or state, there should be included three dis-

tinct accounts for street or road construction: new construction; replacement; maintenance; but, for the purposes of this discussion, we are more particularly concerned in new construction and replacement.

New and old thoroughfares have to be considered in making up a paving program and the engineer's duty is to obtain the best possible construction for the least cost. On an unimproved or undeveloped roadway we have no choice except new construction under the standard methods, but roadways, originally paved with stone block, cobble stone, brick, macadam and gravel, can be considered as a base for a wearing surface of bituminous material. In considering this question we must, of course, estimate if we can the economy to the taxpayer and the economy will be based on, first, the original cost of the old paving; second, its length of service; third, its cost of maintenance; fourth, its condition when resurfaced. It is on the first three points that the speaker desires to emphasize our weaknesses and point out that it is almost impossible to arrive at a value which can be depended upon.

Another point which must not be overlooked, but which is intangible in so far as valuing it in dollars and cents is concerned, is the time saved during the period of construction of the new paving to the abutting property and to the public in general. The speaker has one point in mind which occurred in his office in Richmond just a few months ago. It was found desirable, in order to relieve one of our most prominent main business thoroughfares, to improve a parallel street. This street was first designed for a concrete base, 1½-in. binder, 1½-in. top. Its original pavement was second class granite block. The time assigned for its construction, including the period for the base to set, was 60 days. It was finally determined to allow the old block pavement to remain and resurface with Bessonite. The street varies in width from a 35 to 42-ft. roadway and is 4,000 ft. in length, including a cross street tying up the main thoroughfare. Its area was 13,454 sq. yds. The time saved under the resurfacing method, as compared with the original design was approximately 66 per cent. It is impossible to value this time saving to all concerned but there is no question but that the value is great and should be considered in our plans.

The estimated cost of this street as calculated for concrete base and asphalt topping used, including the hauling away of the spall, would have been $39,366. The actual cost by resurfacing was $23,269, or a saving in money of $16,097, or $1.20 per sq. yd.

There is yet another case in which resurfacing of gravel was used in the place of a concrete base and asphalt top. This street, which is about 1,000 ft. long and 42 ft. wide, was found to have an excellent gravel base and it was finally decided to resurface it instead of placing a concrete base. In this instance the saving was even more. Our estimated cost for concrete base and asphalt top, including the excavation, was $14,662. The actual cost of resurfacing only amounted to $7,874, or a saving of $6,788 in money, or $1.33 per sq. yd.

Where there is a possibility of saving the old bases and utilizing them for resurfacing work, it is the speaker's opinion that a great deal can be saved, and almost, if not as good a pavement, with as long life, be had. Of course, in the resurfacing of granite streets, we cannot hope to have the perfect contour which would be gotten by laying a concrete base to the proper grade, but there is so little difference in the riding qualities of a well resurfaced street and a newly constructed street that the difference is inappreciable. The extra money that can be saved will go that much farther to give the city additional paving.

Although it is impossible to estimate closely the life of granite spall paving, it would seem that if it had given service for 20 years that you might safely say that it had paid for itself and therefore it does not owe you anything.

From the above figures it would seem reasonable to estimate that by resurfacing you really save the cost of a concrete base.

Another point which the engineer should give consideration to is the installation of underground structures such as water, sewerage, gas, etc., and if these structures are to be installed, what will be the condition of the old pavement when he is ready to install the top. The speaker can point, during his 15 years of experience in street paving operations, to any number of old block pavements which were in good condition for resurfacing at the time of the first inspection, but after underground structures were installed, the pavement was practically useless as a base. In the case of old stone pavements, such as granite block, spall or cobble, it is impossible to relay this material as securely as it was before being disturbed. If there

are any number of trenches in the street and an attempt is made to concrete them, it will be found that the expense incident to such construction will largely increase the cost. In such cass, it has been the speaker's experience that the best thing to do is to salvage the old material for replacement purposes on other streets and grade out and install a concrete base. A newly laid block pavement will not give as secure a foundation as it would if left undisturbed and where it had been pounded down by heavy traffic for generations.

Another point to consider is the contour of the old pavement as compared with the contour or cross-section of the new. If this difference is great, it has to be made up of new material. In the case of standard two-course sheet asphalt, the difference is made up by the use of extra binder so as to bring the bottom of the wearing course an inch and a half under and parallel with the finished surface. If of one-course bituminous pavement, such as Bessonite or asphaltic concrete, the difference is made up with the use of the same material, all of which is, of course, an added expense. In citing this, it is the purpose of the speaker to endeavor to show that a minute and careful inspection of the old pavement is necessary before the improvement is started and both before and after utilities are installed. Complications of this sort are bound to arise and it has frequently been necessary to change resurfacing projects to standard construction because these matters were not carefully looked into beforehand. Assuming that the old pavements are in fair condition, resurfacing is a paving proposition and old pavements which have given good and practical service to the public for years, such as stone block, cobble, brick, macadam and gravel, will serve as an excellent base for bituminous pavements.

No matter what the character of the old material to be used as a base, it should be swept clean of all dust and foreign matter. If of stone block or brick it should be well washed, using a hose if necessary, and then well broomed. If the joints are of sand the tops will be blown out to some extent, but this will give the bituminous material an excellent bond. Care should be used not to blow out the joints too deep. It has been the speaker's recent experience that where blown out too deep, unequal compression results, which shows up in the surface of the bituminous material.

If the old material is of macadam or gravel, it should also be broomed clean of all dust and foreign matter. Light sprinkling is sometimes desirable in this case. It is well to cut test holes beforehand so as to obtain the exact thickness of the old roadbed. Not only is this necessary in order to obtain first hand information regarding thickness of base, but very frequently the crown of old macadam roadbeds between curbs is too high, and in attempting to reduce the crown by cutting off some of the old material, the base is sometimes rendered too thin and its usefulness impaired. If contour of old roadbed is too irregular, scarifying and slight resurfacing may be necessary, in which case the surface should be then thoroughly compressed and put under traffic several weeks before beginning resurfacing operations. In case of small depressions in the old surface, the cushion coat is desirable, that is to say, these depressions should first be filled up with bituminous material and thoroughly tamped or rolled; frequently the old material is in such shape that this method will bring it approximately to the proper contour for wearing surface.

With reference to the economical thickness of new bituminous material for the wearing surface, where one course material is used, there is a great diversity of opinion on this subject. The speaker has resurfaced streets of very light traffic, where the original pavement was of well laid vitrified block, with a minimum thickness of wearing surface of ¾ in. Here, however, one has the advantage of a well laid original pavement of good surface and contour. This could not be done with safety where the old pavement is of rough granite or spall. It is safer, however, to establish a minimum thickness of 1¼ in. The maximum thickness depends entirely on conditions and what is necessary to bring the pavement to the proper contour. If over 3 ins. in thickness, it should be laid in two layers, both of them thoroughly compressed. Excessive thickness is to be avoided; if too thick, lack of compression is liable to result as well as excessive cost. Factors of safety in this respect for light traffic are approximately as follows: 1¼ ins. for minimum thickness and 3 ins. for maximum thickness or an average of approximately 2 ins. over the entire area. On heavy traffic streets, however, the minimum thickness should be increased to 1½ ins. and the maximum to whatever depth that is necessary to bring the pave-

ment to a good contour, avoiding excessive depth as far as possible, principally on account of cost.

If the old pavement is of well laid brick, in fair condition, it presents a much simpler proposition. Usually on such pavements a uniform thickness of 1½ ins. throughout can be maintained. If the old brick surface is rough or in pot holes, the method prescribed for rough granite block can be used. While we are dealing somewhat with methods of construction, the question of gutters of some hard material very naturally arises. We all know that bituminous material does not wear well against the curb, particularly on grades under 2 per cent; dampness is almost bound to exist, because all the debris, leaves, etc., finally land next to the curb. It is best to install gutters on all bituminous streets, regardless of grades and conditions. It is true, of course, that the matter of cost arises. Where the matter of parking machines and automobiles does not arise, a narrow gutter of concrete or brick is all that is necessary, say 12 ins. in width; this keeps the bituminous material away from the curb, protects it from dampness and at the same time we all know how difficult it is to roll bituminous material directly against the curb and maintain a good grade. The existence of gutters, no matter how narrow, enables us to maintain a much better cross-section. Where the parking of machines is to be considered, a wider strip, say from 8 to 10 ft. in width, of either concrete or brick, is desirable.

A thoroughfare with a wide bituminous strip through the center, with a strip 8 or 10 ft. wide on each side, between the bituminous material and the curb, of some hard material, such as concrete or brick, can be maintained in a most serviceable condition. It will be found that this section can often be put into use under resurfacing conditions by allowing the old pavement to remain in place under the bituminous strip.

CONSTRUCTION DETAILS ESSENTIAL TO EFFECTIVE HOT MIX PAVEMENTS

By Francis P. Smith, of Dow & Smith, Chemical and Consulting Engineers, 131 East Twenty-Third St., New York City

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., November 8-12, 1926.)

The art of laying Hot Mix Pavements has been developed in this country during the past 50 years. Like most arts with a life history of similar length, it has made great strides, been confronted with changing conditions and has been hampered with bad habits and traditions acquired during the early period of its existence.

For the first 40 years it had to meet the problem of producing a pavement which would successfully carry a slow moving iron tired traffic of light moderate intensity. During the last ten years the density and speed of highway traffic has increased beyond the wildest dreams of human imagination a decade ago and iron tires have been almost entirely replaced by tires made of rubber. This change in the character of the traffic carried by our roads and streets calls for a pavement possessing the same general characteristics as those of the earlier type but with a marked change in their relative value and importance. Methods of manufacture have also been changed and improved and the daily output of single plants has been greatly increased.

Some of the qualities of a hot mix pavement are inherent in the mixture itself and are fundamentally questions of design. Other qualities involve design, manufacture and laying methods, while still others are functions of the last two only.

It is the purpose of this paper to discuss the necessary qualities and the best methods for securing them, except those which are solely questions of design.

The effective life of a modern Hot Mix Pavement is largely dependent upon:

1. The quality of the mixture.
2. The uniformity of the pavement as to:
   - (a) Composition
   - (b) Thickness
   - (c) Density
3. Contour of the finished pavement.

Of equal, if not greater importance, are the kind and character of the foundation, subsoil and drainage but these have been considered by the speaker as falling outside the limits of this paper.

In the earlier days much less attention was paid to these details than is now necessary. The factor of safety was much greater because much less was required of the pavement and this inevitably led to more or less careless work and the acquired habit is hard to shake off. Old-time superintendents and foremen are inclined to jeer at extreme precautions and class them as "old fogeyism," utterly

failing to realize that they themselves are the "old fogies."

The strain of modern traffic is so terrific that it calls for the exercise of the most skillful workmanship to enable even the best of materials to withstand it and this is true of every type of modern pavement. In most instances it costs no more to lay a pavement in accordance with the best modern methods than it does to lay it carelessly. The importance of these factors from the standpoint of competitive design and maintenance costs, cannot be too strongly stressed.

The quality of the mixture is dependent upon its design, the character and uniformity of the materials entering into its composition and the methods of manufacture employed. Eternal vigilance is necessary to insure uniformity and quality of deliveries of raw materials to the plant. The chief variation is found in sand and stone deliveries. If these vary to any great extent, it is impossible to make a uniform mixture out of them. The product of stone quarries and sand pits is far from uniform. Major variations in mesh composition, even if within specification limits, call for variations in bitumen and dust contents of the mixture. If the formula remains unchanged, the mixture will vary markedly in physical characteristics and uniformity will be lost even if quality is not impaired. Dirty stone or sand after passage through the drier frequently has fine dust partly baked on the outer surface of the larger grains or particles. This seriously intereferes with the proper and permanent adherence of the bitumen coating and materials of this type should be rejected.

Adequate temperature control is essential to prevent injury to the bituminous binding material. This applies not only to the heating of the bituminous material but also to the heating of the mineral aggregate. Stone or sand which is too hot will damage the bitumen more seriously in a short time than hours of moderate overheating in a large kettle. In order to secure proper bond between the bitumen and the aggreate all moisture must be driven out of the aggregate and it must be heated to the correct temperature to facilitate mixing and insure delivery on the work at such a heat as will be most favorable to laying and compression. Too low a temperature increases the difficulty of properly and uniformly coating the mineral aggregate with bitumen and makes a mixture which is difficult to rake on the street and impossible to compress effectively. Varying percentages of moisture in the aggregate call for variations in drum temperatures which must be carefully watched. Electrical pyrometers if properly used not only indicate temperatures but are of great aid to the fireman and result in increased output as well as necessary uniformity of mixture. Notwithstanding this, the speaker has had their installation bitterly opposed by foremen by the reason that they would seriously curtail the plant output! The logical deduction to be drawn from such an argument is too obvious to require further comment. Undoubtedly the future will see the widespread development of automatic thermostatic control.

Mixer teeth in good condition, shafts operating at proper speed and sufficient time given are extremely important. The mineral aggregate must be evenly, uniformly and completely coated with bitumen. Too often mixer teeth that are half worn down are kept in service and the time of mixing reduced to increase the output. This results in a mixture in which some of the particles are imperfectly coated with bitumen and some parts of the mixture are excessively rich at the expense of other portions which are too lean. Such a mixture is especially liable to wave under heavy traffic.

Thorough adherence of the bitumen to the mineral aggregate is greatly increased by the sustained attrition of the particles for an appreciable period of time. The principle is the same as that involved in thoroughly brushing out the coat of paint applied to a surface for protective purposes. It is absolutely essential that the film of bitumen should be strongly adherent to enable it to successfully resist water action, weathering and the movement of the particles of the mineral aggregate under traffic stresses.

Uniformity is perhaps a greater aid toward retarding wave formation than is generally recognized. A pavement in which soft rich spots occur surrounded by a notably harder mixture is much more liable to form objectionable waves and lumps than one which is uniformly soft. In the latter case the displacement will be less localized, i. e., will be distributed over a larger area, and will have a tendency under certain conditions to heal under traffic, which will be noticeably absent in the former case.

Uniformity of composition is largely a matter of plant control. It is dependent upon uniformity of raw materials (chief-

ly mineral aggregate), accurate weighing and thorough mixing. If any of these are slighted a non-uniform pavement will result. Another source of danger is segregation during transit between plant and street. The coarser aggregates are particularly liable to this, more especially if they are poorly graded and lacking in intermediate sizes of stone, particularly ¼-in. and ½-in. particles. Most specifications are very lax or indefinite in their requirements as to the amount of ¼-in. material which the mixture should contain. When mechanical spreading is employed it is difficult to correct segregation. With hand spreading it is possible to correct it by turning the mixture over with shovels before putting it in place and this should always be done in the case of coarse aggregate wearing surface. It is perhaps unnecessary with binder except in extreme cases. The appearance of the average binder course after laying, especially where intermediate sized stone is absent, plainly shows the extent to which segregation takes place in coarse aggregates during transit.

Uniformity of thickness is chiefly dependent upon the grade of the finished base and the care exercised in raking. It used to be almost an axiom in the bituminous paving industry that any errors in the grade of the base would be remedied by the binder and these in turn by the top and as it was desirable to have the surface of the concrete or other base rough in order to prevent the bituminous mixture from sliding on the base, this precluded the possibility of laying it accurately to grade. This fallacy led to a widespread disregard of the contour and grade of the finished base which is all too prevalent at the present time. It would appear to be axiomatic that a bituminous wearing surface of greatly varying depth is more liable to displacement under heavy traffic than one of uniform thickness and yet it is very difficult indeed to convince engineers of the necessity of fine grading their concrete foundations. The speaker at times feels like advocating the use of a template or paving gauge on both the foundation and the finished surface. Roughness of surface should be made subordinate to maintaining grade and can be obtained by the use of corrugated rollers, vibrating mats or similar devices.

The raking of the hot mixture is usually done by eye. Here again a gauge would be an improvement. It takes many months to make a good raker out of a man who is fitted for the work and many men never become good rakers. In former days when the plant output was less than at present and horse-drawn wagons delivered the hot mixture on the street, there was sufficient interval between the loads for the head raker to go over the work of the other rakers and correct their errors. Today this is rarely done. There is no time available and in the speaker's judgment there are fewer good rakers, or possibly the demand for them has increased, which amounts to the same thing as far as any one job is concerned. The use of a long handled screed 4 to 5 ft. in length, operated at right angles to the direction of raking, after the raking is completed, will correct many of the errors of poor raking. Careless methods of spreading or too small a street gang to handle the plant output frequently necessitates standing in the hot mixture. This inevitably causes variations in thickness unless the mixture where trampled upon is "fluffed" up to the same density as the balance of the mixture by the rakers. With a stiff mixture this is hard work and rakers will not do it conscientiously and thoroughly all day. With the plant pushing the street gang to the limit of their capacity to do good work, this will inevitably happen. The remedy is to increase the street gang, but with a narrow roadway this cannot be done beyond a certain point.

The density of a pavement is dependent upon its design and the amount of compression it receives. In order to secure maximum stability it is essential that rolling should be applied and continued in such a manner as to produce as nearly as possible, ultimate compaction. Here again tradition hampers, for in former times areas which were not fully compressed when the pavement was laid received their final compaction under traffic and in most cases no great harm resulted. The danger of such a practice is increased one hundred fold today. Inadequate roller equipment is all too common and the fault is partly due to lack of realization of what is necessary to properly handle the large output of modern plants. Increasing the speed of the rollers decreases their compressive effectiveness and tends towards faulty contour. More rollers are required and must be used and they must be kept continually in operation. The delays incident to cleaning fires and filling up boilers with water have led many contractors and county organizations to turn to

the motor roller. The clutch mechanism of this type of roller has recently been greatly improved but it is absolutely necessary to maintain it in perfect condition, otherwise the jerks incidental to starting and reversing will be fatal to good contour.

Dense modern mixtures require the use of a heavy roller for initial rolling. After such mixtures become slightly chilled it is impossible to effectively compress them. Twelve and fifteen-ton three-wheel rollers are being increasingly used for this purpose instead of the former five to eight-ton tandem roller. They should be put in use just as soon as the freshly raked mixture will take them and no delays should be tolerated. This precaution is especially essential in cool weather.

Effective raking is a necessary adjunct to effective compression and a close inspection of the surface after the first rolling clearly shows this. If the raking is poor, the surface of the freshly rolled mixture will show a number of honeycombed spots. These are due to the fact that the full weight of the roller has not been applied to them because it has been chiefly supported by adjacent humps. These humps must be displaced before the low spots can receive proper compression and that means that more rolling will be necessary and if the humps are large or the street is too narrow to permit diagonal rolling, it is questionable whether uniform density will ever be obtained through rolling.

When the pavement is subjected to traffic, these partially compressed areas may, under favorable conditions, receive final compaction. If they do not, they will probably ravel out sooner or later, leaving a hole. If they do, a slight depression will be formed, which under heavy traffic and unfavorable conditions, will diminish the effective life of the pavement and increase its tendency to wave. Uniform density of the finished pavement calls for good workmanship at every stage and slackness or inefficiency in any one operation can only be remedied, if at all, by increased labor and expense in the subsequent stages.

Under former conditions extreme smoothness of contour was not essential. If there were no low spots which would hold water, it was considered satisfactory and no discomfort was experienced in riding over it at the maximum speeds prevalent at that time. Unevenness of contour to modern high speed traffic means discomfort, and if extreme, danger and greatly diminished life. A comparatively small depression starts up spring vibration and enormously increases the force of impact which is so destructive to all our modern highways. It also localizes the point of impact and this results in progressively increasing it to a point where no type of construction will withstand it.

Once more eternal vigilance is the price of uniformity of contour. A straight edge should be continuously used to check up the contour after the first rolling, at which time serious defects are most easily and cheaply remedied. The screed previously mentioned, if properly used, acts as a short preliminary straightedge which is easily and quickly applicable to any doubtful spot at the time when the defect can be remedied with maximum ease and effectiveness.

The careful leveling of joints must be given close attention if uniformity of contour is to be maintained but this is secondary in importance to good workmanship in raking and rolling for the reason that the joints occur only infrequently.

Summary

In conclusion the speaker would urge recognition of the following facts and cardinal principles:

1. That in all types of highway construction whether of portland cement or bituminous concrete the factor of safety and the inherent qualities of the mixtures used are such as to imperatively require the best grade of honest and efficient workmanship.

2. Foundations must be adequate and no foundation can be commercially adequate without proper provisions for drainage.

3. The slighting of any of the stages of construction work with the idea of remedying it later on is expensive and inadequate and cannot produce a satisfactory result. This applies especially to the strict adherence to established grades for the various portions of the pavement.

4. Apart from design, uniformity of mixture, density and contour are the three most essential points.

5. **Plant:** Test all materials delivered —control temperatures and mixing periods—accurately proportion ingredients and bend every effort towards sending out uniform mixtures.

6. **Street:** Insist on proper spreading, raking and rolling and adequate equip-

ment and number of men. Require strict adherence to established grades for the various courses of the pavement with special attention to the final surface.

THE STORY OF TWO OLD HIGHWAYS

By Leroy F. Wertz, Assistant Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis

The Michigan Road In Indiana

The Michigan Road was built in accordance with the terms of the Mississinewa treaty of 1826 with the Pottawattamie Indians. Article II of the treaty reads as follows: "As an evidence of the attachment which the Pottawattamie tribe feel toward the American people, and particularly to the soil of Indiana, and with a view to demonstrate their liberality and benefit themselves by creating facilities for traveling and increasing the value of their remaining country, the said tribe do hereby cede to the United States a strip of land, connecting at Lake Michigan and running thence to the Wabash river, 100 ft. wide, for a road; and also one section of good land contigous to said road for each mile of the same and also for each mile of a road from termination thereof, through Indianapolis, to some convenient point on the Ohio river, and the General Assembly of the State of Indiana shall have a right to locate the said road and apply the said sections, or the proceeds thereof, to the making of the same, or any part thereof, and the said road shall be at their sole disposal."

The general direction of the Michigan Road is as follows:

Beginning at Trail Creek on Lake Michigan (Michigan City), the road takes an easterly course to the southern bend of the St. Joseph River (South Bend). It then turns south and runs down to the Wabash River (Logansport), which it crosses and then continues south to Indianapolis. From this point it inclines a little to the southeast to reach the town of Greensburg. From Greensburg it takes as straight a course as possible to Madison on the Ohio river. The road from Indianapolis to Madison is not as straight as the northern part of the road, for the lower half was marked out through parts already quite thickly settled and the road in many places had to take the course of roads already laid out.

January 29, 1830, an act was passed to provide for opening that part of the road lying between Madison and the Wabash river 100 ft. wide in the following manner: "All parts of the road were to be cleared off leaving no stump more than one foot above the level of the earth; and grubbed 30 feet wide in the center of the road as the United States road (Cumberland or National Road) was grubbed through Indiana." Noah Noble was appointed contract commissioner to carry the provisions of the act into effect.

Late in 1831 Noble became Governor and William Polke was appointed contract commissioner. In 1832 he had let contracts for bridging streams, causeways swamps, ditching, etc., covering the road from Madison to Logansport (a distance of 162 miles) for $16,621.50 or an average of $102 per mile.

February 2, 1832, an act was passed to open up the northern division between Logansport and Lake Michigan. Accordingly, the road was opened 100 ft. wide and contracts were let over the 102 miles for $29,325 averaging about $287.50 per mile. The cost of the northern section was more than that of the southern section for the reason that this part was opened through wild, unbroken forests, prairies and swamps while the southern half had run through parts already settled in which roads had formerly been cut, along which the Michigan Road was laid.

The work of surveying began in 1828, the first contracts were let in 1832 and by 1837 the entire road had been built.

One reason for the slow progress in building the road was the lack of available funds, which funds had to be secured from the proceeds realized from the sale of lands. Settlers were afraid of the Indians and did not buy the lands as readily as had been anticipated, although the land sold at from $1.25 to $7,50 per acre, the first figure being the price paid when the road was started and the latter the price paid as the road neared completion, thus showing the enhancement in land values as the road proceeded.

It was 264 miles in length and the total expenditure as given by the Auditor of State was $242,008.04. The receipts from sale of land is given as $241,331.89 with several hundreds of acres of land still to be sold.

In 1837 according to an act approved February 3, 1837, the tools and implements used on the Michigan Road were sold. The sum realized was $100.

It is evident that the Michigan Road was a self-supporting enterprise as was

intended and the state suffered no loss in its construction.

The National Road

The National Road was one of the most important steps in the movement of national expansion. It was first needed to connect the Atlantic seaboard with the rich, undeveloped Ohio Valley or more particularly that country lying north and west of the Ohio river comprising the Northwest Territory and usually spoken of in the early days as the "Ohio country." The National Road was sometimes called the "United States Road" or "Cumberland Pike" and is today a part of U. S. Highway No. 40.

By an Act of Congress, April 30, 1802, the people of Ohio were enabled to form a constitutional government. It was therein provided that 2 per cent of the proceeds of the sales of public lands within her limits would be held and applied in the construction of a public highway leading from some point on the of her public lands for similar purpose. March 29, 1806, an act was approved to regulate the laying out and making of a road from Cumberland,Mar yland, to the Ohio River near Wheeling, West Virginia. This act also specified that the road be 4 rods (66 ft.) in width and in no instance have an elevation, when finished, greater than an angle of 5 degrees with the horizon.

Before the government could start the work, it was necessary to have the consent of each state through which the road passed. In February, 1808, President Jefferson reported to Congress that the consent of all states had been obtained. Pennsylvania was the only state that stipulated any certain requirements, and those were that the road should pass through Washington and Uniontown.

April 16 and May 11, 1811, the first contracts were let and covered ten miles of the road west of Cumberland, Maryland. These contracts were completed the following year. Contracts let in 1812, 1813, 1815, and in 1817 contracts brought the road to Uniontown, Pennsylvania. In 1818 it was completed to Wheeling. The route was 24½ miles in Maryland, 75½ miles in Pennsylvania and 12 miles in Virginia, a total of 112 miles, and was seven years in building. The estimated cost had been placed at $6,000 per mile not including bridges. The cost of the road from Cumberland to Uniontown was $9,745 per mile. The cost of the entire division east of the Ohio river was about $13,000 per mile. In crossing the mountains, the highest elevation was 2,328 ft.

Four four years the fate of the road west of the Ohio hung in the balance because of the perplexing question—had Congress the power to appropriate the public money for carrying on a general system of internal improvement? This question entered into political discussions and divided the people. In 1822 President Monroe vetoed a bill passed by Congress "to establish turnpikes with gates, and tolls and to enforce the collection of the tolls." However, in 1824 he signed a very similar bill, the difference being that the respective states through which the road passed collected the toll instead of the United States Government. The government would place the road in good repair and then turn it over to the states to maintain. These repairs were made by removing the old metal and rebuilding a macadam surface 30 ft. in width and 6 ins. in depth. All the construction of the road and repairing was done by the government under the supervision of the Department of War.

March 3, 1825, Congress passed a bill appropriating $150,000 for building the road to Zanesville, Ohio, and extending the surveys to the permanent seat of Government in Wisconsin, to pass by the seats of government of Ohio, Indiana, and Illinois. The road crossed Ohio in a due line west, not deviating its course even to touch cities of such importance as Newark or Dayton. The preliminary survey westward was completed in 1826 and extended to Indianapolis, which became the center of National Road operations in Indiana, and from this city the road was built both eastward and westward. The division from the Ohio river west was built 80 ft. wide.

Appropriations for the work in this state were made by Congress in 1831, 1832, 1833, 1834, 1835, 1836, 1837 and 1838. At about this time the panic of 1837-40 was being felt and no more appropriations were granted.

In 1848 Congress passed an act surrendering the "National Road" to the various states. It was built approximately 700 miles long, cost $6,824,919 and occupied the public mind for half a century. Of the $6,824,191 appropriated by Congress for making, repairing and continuing the road $1,136,600 was allotted to Indiana and of this amount $513,199 was spent for bridges and masonry.

When Indiana and Illinois received the road from the National Government it was not completed, though graded and

bridged as far west as Vandalia, then the capital of Illinois.

In Indiana, the Wayne Co. Turnpike Co. chartered by the State took over 22 miles in Wayne County, graveled the road and operated it as a toll road until 1894, when it was purchased by the several townships through which it passed and made free of tolls. The portion in Henry County was secured by a private corporation, graveled and made a toll road about 1853. In 1849 the Central Plank Road Company was granted that portion of the road extending from Henry County to Clay County for the purpose of constructing a plank road.

REPAIR COSTS OF RURAL PAVEMENTS

By Frank A. Thomas, City Engineer of Euclid, Ohio, former Paving Engineer of Cuyahoga County

(From a paper presented before the 1926 meeting of the American Society for Municipal Improvements.)

At the 1925 meeting of this Society, Mr. Simpson, City Engineer of Columbus, Ohio, read a paper on the "Repair Costs of City Pavements." This paper that I am reading to-day is a similar one with the exception that the pavements are rural.

City pavements are seldom less than 24 and up to 60 ft. or more in width. Curbs are raised, with an exposed face 4 to 8 ins. above the surface of the pavement. Catch basins and sewers take care of surface drainage.

Rural pavements referred to in this paper, are from 8 to 20 ft. wide, with flush curbs, and open side ditches to take care of surface drainage.

These rural pavements on which repair costs are herein quoted are located in Cuyahoga County, Ohio, of which Cleveland is the county seat.

When I say "rural pavements," I refer of course to pavements that were considered rural when they were designed and constructed. Cuyahoga County built its first rural pavement in 1896. This county was a pioneer in rural highway improvement and had most of its main arteries leading out of Cleveland either partially or entirely paved with brick by the time other progressive communities of the country were beginning to think along these lines.

Cuyahoga County's leadership in this respect was so pronounced that in the earlier days, when the advent of the automobile brought the need for improved highways so forcibly to our attention, engineers and officials from all parts of the country, as well as from foreign countries, came to Cuyahoga County to study its pioneering efforts.

Some of these early pavements are still in service, but actually several of them are no longer rural pavements. We find them the main business streets in thriving communities that have developed along the county's main arteries. We find them carrying the very heaviest city traffic in addition to the through traffic. In some cases they have been widened, with the old pavement still doing service either in the center or at one side.

This condition brought about by the very rapid growth of Cleveland must be taken in consideration when analyzing the maintenance data contained in this paper.

The first pavement built in 1896 was only 8 ft. wide. It had a 4-in. vitrified brick, cement grout filled surface, laid on a 1-in. sand bedding course. The base was of broken stone 6 ins. deep. The curbs were of sandstone 4 ins. wide and 16 ins. deep, set flush with the brick surface.

Between 1896 and 1903 several of these 8-ft. pavements were built, one of which is still in service. Though of ancient design, it still carries modern traffic.

In 1903 the standard width was increased to 14 ft. and in 1909 the type of base was changed to concrete. The concrete was a 1-2½-5 mix and 4 ins. thick. Concrete curbs were used generally from 1909 on, but not exclusively.

I have said that our stone bases on these early pavements were 6 ins. deep and our concrete bases 4 ins. deep, and of 1-2½-5 mix. Perhaps I should add a word here concerning the strange phenomenon noticed within the last few years.

In repairing some of these pioneer pavements we have found that, in some instances, part of the crushed stone or the concrete as the case may be, has entirely disappeared. As much as an inch or two seems to have been entirely absorbed or in some manner dissipated. Six inches of stone sometimes has shrunk to 4 ins, and 4 ins. of concrete to 3 ins. or even 2 ins. It is very strange.

Perhaps some of you gentlemen here have noticed this same phenomenon in your own respective communities, and perchance you have reached the same

conclusion that we have been forced to, namely, that the builder in those bygone days was prone to make mistakes, or when he left his ruler at home, was a poor judge of base thickness.

In 1915 the concrete and macadam type of pavements were introduced and the width increased to 16 ft. In 1917, asphaltic concrete on a Portland cement concrete base was first laid.

The monolithic brick type as well as brick and cement-sand bedding course was used on several pavements between 1915 and 1922. In 1922 the standard width was increased to 18 ft. In 1923 asphalt filler was substituted for cement-grout.

This rural highway system has nearly 400 miles of pavement and is made up of 140 separate improvements.

There are four general types of pavements:

Brick leads with a yardage of 2,058,399 or 65% of the total; concrete with a yardage of 592,213 or 18%; macadam with a yardage of 349,284 or 11%, and asphalt with a yardage of 208,361 or 6%.

The Brick Type

The 4-in. paving brick was used on 96% of the 2,058,399 sq. yds. and the 3-in. paving brick on the balance.

Cement grout filler was used on 91% of the yardage and asphalt filler on 9%. Plain sand or granulated slag cushion or bedding course was used on 87% of the yardage, cement-sand 1-3 mix, on 3%, and 10% was laid on the green concrete base, making the so-called monolithic type. Of the total yardage, 18% is on a 6-in. broken stone base, 63% on a 4-in. concrete base, 7% on a 5-in. concrete base, 4% on a 6-in. concrete base, 7% on a 7-in. concrete base and 1% on an 8-in. concrete base. Steel reinforcing was used on 12% of the concrete base yardage. (I prefer to call it steel "binding" because it was so light that it did not amount to much as reinforcing.) Stone curbs were used on 25% and concrete curbs on 75% of the yardage.

The repair cost on the brick pavements is low and rises gradually for the first ten years, after which it rises rapidly, and in the twelfth year it has doubled; in the fourteenth year it has quadrupled and in the eighteenth year it is nearly eight times as much. After the eighteenth year it runs uniformly for the next three years. At the age of 7 years the repair cost per sq. yd. per year was about ½ ct.; at 14 years, 4.2 cts.; at 21 years, 8 cts.

It must be remembered in considering this rapid increase in repair costs after the first ten years, that the writer is referring to pavements designed and built before even the most visionary engineer could intelligently foresee the enormous traffic they would be called upon to carry. It is noted that this period of sharp rise in repair costs starts at about the time that the gasoline motor brought to our streets and highways an intensity and weight of traffic never anticipated by the engineers who designed them.

The repair costs given in this paper are for slab maintenance only. They were determined by taking the amount of money spent for repairs on the several improvements each year and dividing that amount by the total yardage in service during each year. The result was the repair cost per sq. yd. for each year. The cost per sq. yd. per year is the quotient of the accumulated amount of money spent for repairs on any period of years, divided by the number of years in that period.

As an example, there were 2,058,399 sq. yds. of brick pavement that were in service one year, on which nothing was spent for repairs, making the cost per sq. yd. for the first year nothing. There were 1,898,227 sq. yds. that were in service two years, on which was spent the sum of $2,753, making the cost per sq. yd. for the second year 14 hundredths of a cent. There were 1,875,359 sq. yds. that were in service three years, on which was spent the sum of $4,222 during the third year, making the cost per sq. yd. for the third year, 22 hundredths of a cent. Now the accumulated cost per sq. yd. for three years is the sum of nothing for the first year, 14 hundredths of a cent for the second year, and 22 hundredths of a cent for the third year, or a total of 36 hundredths of a cent. The cost per sq. yd. per year for a three-year period would be 36 hundredths of a cent divided by three, or 12 hundredths of a cent.

Remarks on the Brick Type

On 1,524,640 sq. yds. the repair cost for ten years was 12½ cts. a sq. yd., or 1¼ cts. per sq. yd. per year.

On 1,073,342 sq. yds. the repair cost for 13 years was 38 cts. a sq. yd. or 2 9/10 cts. a sq. yd. per year.

On 680,253 sq. yds. the repair cost for 15 years was 76 cts. a sq. yd. or 5 1/10 cts. a sq. yd. per year.

On 112,719 sq. yds. the repair cost for 20 years was $1.60 or 8 cts. a sq. yd. per year.

One-half of the total repair cost was spent on these pavements of early design, built between 1904 and 1909. Much of this cost has come with the unexpected heavy traffic. These pavements have a non-rigid base of broken stone 6 ins. thick and the yardage is 18% of the total.

Two-thirds of the total repair cost was spent on seven roads having less than 20% of the total yardage. These were, of course, the heaviest traveled of the brick roads, our main arteries. The repair cost on these seven roads equals 90% of their initial cost. One-half of the total repair cost was spent in the twelfth, thirteenth, fourteenth and fifteenth years.

Several of the old brick pavements this year (1926) are being reconstructed by widening and resurfacing, and in these cases it is possible to determine a salvage value, and the total pavement cost per square yard per year of the pavement.

One pavement in particular is being resurfaced with asphaltic concrete. The original cost of the old brick pavement was $1.81 a square yard. It has given 20 years of service with a repair cost of $1.60. The interest for 20 years at 5% is $1.81, making the total cost $5.22. The salvage value or the worth of this old pavement as a base is at least $1.75. The net cost will be the difference or $3.47 for 20 years of service or 17.4 cts. a square yard per year. At this rate an 18 ft. pavement would cost less than $2,000 a mile per year.

The pavements that required the most repairs were the heaviest traffic routes, on clay soils, which had a low supporting value. Faulty drainage undoubtedly was the major cause of many of the repairs.

The average original cost per square yard for all brick pavements was $2.50. The average original cost per square yard for brick pavements built between 1915 and 1925 was $3.42.

Since two-thirds of the brick yardage was built prior to 1915 on a 6-in. broken stone or 4-in. concrete base, only 14 ft. wide, and designed primarily for horse drawn vehicles, these brick pavements have a very reasonable repair cost.

The brick pavements built between 1915 and 1925 have a lower and more uniform repair cost than the other types of pavements.

In Cuyahoga County, pavements have been financed by 10 year bonds and any pavements that require excessive repairs during this period may justly be considered as a failure. There has been no failure in the brick type.

There is no doubt but what the grout filler in the brick surface added greatly to the strength of these old pavements with thin weak bases, and was one of the reasons why they stood up so well.

The Concrete Type

The first concrete pavement was completed in 1915 and from this time to 1925 a total of 592,213 sq. yds. have been laid. Several different designs were used. About 60% of the yardage was laid in two courses and 40% in one course. The first course in the two-course jobs was of a 1-2½-5 mix, except one job which had a 1-2-4 mix. The second course was a 1-1½-2½ mix on about one-half of the two course yardage and a 1-1-2 mix on the other half.

All of the two course jobs were laid on a flat subgrade and were 6 ins. thick at the sides and 8 ins. in the center, except two jobs which were 7½ ins. at the sides and 9½ ins. in the center. Several of these two-course jobs had 8 by 10 in. concrete beams reinforced with 2½ in. square bars under the edge at each side of the slab.

The one-course jobs are all 8 ins. thick and of 1-1½-3 mix. Reinforcing steel was used on all jobs except two. The concrete roads are 16 to 18 ft. wide.

The repair costs per square yard per year, on concrete pavements from 1915 to 1924, run at 0 for first year and less than 1ct. for the second, third and fourth years. For the fifth year, 3cts.; sixth year, 4.8 cts.; seventh year, 8 cts.; eighth year, 12½ cts.; ninth year, 16 cts, and tenth year, 15 cts.

Remarks on Concrete Type

Because much of the concrete yardage in the County has not passed through what might be termed the critical period, the writer purposely refrains from drawing any definite conclusions. Generally speaking, but with some few exceptions, the concrete pavements all located on secondary roads, have stood up fairly well. One pavement was a complete failure, and the cost of repairs on this one job was much more than its original cost. This amounted to 80% of the total repair cost of all concrete roads. The yardage of this pavement was about 4% of the total.

The pavement had a flat surface on the subgrade and was 6 ins. thick at the

sides and 8 ins. in the center. It was built in two courses, the first course being a 1-2½-5 mix and the second a 1-1-2 mix. The subgrade soil, as is the case under many of our pavements of whatever type, was a heavy clay with poor drainage. This poor drainage was a major cause of failure. The average original cost per square yard for all concrete pavements was $3.

The Macadam Type

The macadam type of pavement was first used in 1905, and between this date and 1925 there were 19 roads improved with this material.

Of the 349,284 sq. yds., 40% was built in two courses and 60% in three courses. The top or surface course on 70% of the yardage had a bituminous binder applied by the penetration method, tar being used on nearly all jobs.

The surface course on 30% of the yardage was water-bound, and practically all of it has been surface treated with a bituminous material one or more times since it was placed in service. Crushed slag was the aggregate used on all the jobs.

The first course was 5 ins. thick on all jobs except three, on which it was 4 ins. The second course was 5 ins. on the two-course water-bound, 3 ins. on the two-course penetration and 4 ins. on the three-course jobs. The third course was 3 ins. thick.

The macadam roads are 16 to 18 ft. wide.

Macadam pavements have a high repair cost which starts shortly after construction. The repair costs on macadam pavements, from 1915 to 1924, per square yard were: 1st year, 0; 2d year, 3 cts.; 3d year, 7½ cts.; 4th year, 12½ cts.; 5th year, 11 cts.; 6th year, 17½ cts.; 7th year, 17½ cts.; 8th year, 18½ cts.; 9th year, 18 cts., and 10th year, 27½ cts.

Remarks on Macadam Type

Twenty-eight per cent of the total cost of repairs was spent on one improvement.

Sixty per cent of the total cost of repairs was spent on 94,772 sq. yds., which is less than 30% of the total yardage. This 94,722 sq. yds. has been in service 5 to 10 years.

Judging from Cuyahoga County's experience, repair costs equal first cost at the age of ten years. A stretch of over a mile on a macadam road built in 1915, was practically ruined by trucks that were hauling material for the construction of a new pavement. This same traffic passed over a 15-year-old brick pavement and did no apparent damage.

A three-year-old penetration macadam pavement, 11 ins. thick, built in three courses, was damaged so badly by three months of truck traffic that it had to be resurfaced. This same truck traffic passed over a concrete road that was four years old and did no apparent damage. The first cost of the concrete road was a little over a dollar a square yard more than the first cost of the macadam, but the first cost of the macadam plus the cost of repairs and resurfacing at the end of the third year, was greater than the cost of the concrete.

Nearly all of the macadam pavements are on clay soil. The average original cost per square yard for the macadam pavements was $1.95.

The Asphalt Type

The first asphalt type of pavement on this system was completed in 1917, and from 1917 to 1925 eight improvements were made using this type.

Of the 208,361 sq. yds., 88% is an asphaltic concrete 2 ins. thick, and 12% is a sheet asphalt 1½ ins. thick, on a 2 in. binder.

The base under one section of the sheet asphalt type was an old brick pavement, and under the other section an old stone block pavement. The base under the asphaltic concrete is either concrete or macadam.

The thickness of the concrete base varies; 23% of the yardage is on 7 ins. of concrete, 3% on 6 ins., and 37% on a base that is 6 ins. thick at the sides and 7 ins. in the center. The concrete base is a 1-2½-5 mix. Reinforcing steel was used in 23% of the yardage.

The macadam base is 10 ins. thick, built in two 5-in. courses. Twenty-five per cent of the yardage is on this type of base.

The repair costs of asphalt pavements, from 1917 to 1924, per square yard per year ran: 1st year, 0; 2d year, 5½ cts.; 3d year, 9 cts.; 4th year, 27½ cts.; 5th year, 25 cts.; 6th year, 22½ cts.; 7th year, 21 cts.; 8th year, 20 cts. per sq. yd.

Remarks on Asphalt Type

Ninety per cent of the total repair cost was spent on one road which was a complete failure. The repair cost of this pavement was more than three times its first cost. The base under this pavement was 6 ins. thick at the sides and 7 ins. in the center. The subgrade was a clay soil with low supporting value.

The traffic on this road was heavy, a large part being truck traffic.

This county's experience with asphalt pavements has been so limited and the results so erratic that the cost data is of little value.

The average original cost per square yard for the asphalt -pavements was $2.84.

Traffic

A recent traffic survey on the principal highways in Cuyahoga County revealed a traffic on some of them amounting to 3,500 tons per day between the hours of 6 A. M. and 6 P. M. Figuring only 300 days in the year, this would total an annual tonnage of 1,050,000. It is reasonable to estimate that these pavements of early design and construction, built for light and slowly moving vehicles, have been carrying on an average of one million tons of modern traffic per year for at least the last five years.

The brick pavements being the type first laid in the county, naturally were laid on the principal traffic arteries and closest in to the city. Several of our heavy traffic routes are also paved with asphaltic types.

Conclusions

In the rigid types of pavements, the two things responsible for the bulk of maintenance costs, were, unstable subgrades, inadequately drained, and weak, inferior bases. This fact is established by the excellent conditions of those sections of these old pavements that are found on sandy or gravelly soil.

In the non-rigid types, the principal causes for much of the repair necessary, are under-design, cutting of the thickness to obtain a low first cost, and poor judgment in placing unsuitable types of pavement on roads where traffic and soil conditions demanded a better type. It is evident that it would have been more economical to have rebuilt or reconstructed those pavements that required excessive repair, rather than to have kept them in service by patching them from time to time.

One of the surprising things brought out from this study of repair costs. is the excessive repairs made to pavements of some types built since 1915. Several have had considerably more than their first cost spent in repairs, and this, too, before they had rendered ten years of service. In short, property owners needed a new pavement before the ten year bonds on the old one had been retired.

Mr. Simpson from his studies of repair costs on city pavements in Columbus, Ohio, found a critical period in the life of heavy traffic pavements. This period was from nine to thirteen years. Cuyahoga County's experience seems to prove this critical period to be at about the same time.

However, we must realize, both in the case of Columbus and Cuyahoga County, that we are considering a large yardage of pavements that were designed and constructed either before the advent of heavy traffic as we know it today, or during the early phases of this heavy traffic. Whether this same critical period is to be found nine to thirteen years hence in pavements designed and constructed today, is another question.

In conclusion I think it behooves engineers who are designing pavements to put more of the "repair cost" in "first cost" instead of letting some road commissioner put it in later in "after cost."

CONTRACT WORKING TIME AND LIQUIDATED DAMAGES

(Editor's Note: The following is a recent bulletin from W. H. Connell, Engineering Executive and Acting Secretary of Highways to all Division and District Engineers and Contractors, of the Pennsylvania State Highway Department.)

Time is an essential element of a contract and in order that there be true competitive bidding, the time allowed must be stated in the proposal and understood by all.

The charging of contract time must be considered impartially as the interests of the public and the contractor both are involved. The policy of the Department and the method of charging working time in the field, stated briefly, is as follows:

The Department's Form No. 476 is used for indicating the basis upon which the Department has determined the contract working time. This analysis of time and allotment to the various major operations will be considered satisfactory unless the contractor chooses to use a different plan and schedule. If he chooses to do this he shall discuss the matter with the district engineer and obtain his approval and a new Form 476 shall be worked up and used as the basis of operation in checking the contract working time.

Legal time is the correct working time after the legal starting date and is used for determining liquidated damages. The actual time includes any time used previous to the legal starting date plus the

legal time and is used for determining the actual progress and cost of the various items.

The district office, upon receipt of a notice of execution of a contract, will notify the contractor to begin operations on a stated date providing he has not done so in the meantime. This date usually is ten days from the date of the letter to the contractor and the charging of working time begins at the time stated in the notice. If the contractor has begun operations, working time is charged from the date of notice-to-proceed given to the contractor.

As the remission of working days or extension of contract time is vested entirely in the Secretary of Highway or his deputy, the inspector is instructed to charge time for every day or fraction of a day with the exception of legal holidays and Sundays, when the weather will permit work on the major controlling operations and he has no alternative. He is instructed to keep an accurate record for all delays and their causes, these being submitted to the district engineer for his consideration.

The controlling major operation may be defined as that operation which controls the progress of the contract at any time. Generally speaking, grading will be considered the major controlling operation until such time as the schedule provides for the starting of the base course or surfacing. If the contractor continues to grade after paving is scheduled to start and weather conditions would not permit paving, no time shall be charged, based upon the consideration that the surfacing operation will require the scheduled amount of time for its completion and is the major controlling operation at that time, regardless of the grading. Very frequently the contractor desires to continue grading operations during the winter months while the grading operation is still the controlling major operation. In this case, time will be charged proportionate to the work accomplished to that scheduled, until such time as the grading operations cease to be the controlling major operation, and from that time on no charge will be made for grading.

In order that the contractor may be fully informed of the time charged on any particular project, the district engineer is instructed to notify him monthly of such charges and request an immediate discussion of any exceptions the contractor desires to take. If the district engineer concurs with the contractor, he will advise him that he will recommend such remissions to the Secretary of Highways for his consideration.

The principal causes for recommending remission of working time are equipment breakdown, embargoes or failure to obtain delivery of material, delays due to public service companies' failure to remove or relay structures within the limits of the work, and increasing items in the contract. No remissions will be considered for causes other than those over which the contractor has no control, or for which he is not responsible. The contractor is considered responsible for supplying labor and materials and only in extremely exceptional cases, where it is shown that the contractor has used every practical means to meet this requirement and has failed through no fault of his own, will remissions be considered.

Adjustments of contract time for increased or decreased quantities will be made at the rate of progress indicated in the schedule, or at a satisfactorily lower rate of progress according to the conditions, which will be determined by the engineer.

Failure to anticipate conditions and to complete minor operations which delay any controlling major operations will be considered the contractor's responsibility.

The district engineer's recommendations will be considered by the Secretary of Highways each month providing the remission recommended amounts to at least 10 per cent of the original time allowed in the contract.

When operations are discontinued during the winter months, the district engineer is instructed to notify the contractor in the spring that operations must be begun on a given date and time will be charged from that date and carried along in the same manner as on a contract just executed, providing however, the contractor has not begun a controlling operation before the given date, when, in such cases, time shall be charged from the beginning of such operation. Reasonable time for closing down work in the fall and resuming in the spring will be allowed without charging time.

Liquidated damages are provided in the contract and are assessed for two reasons: First, the expense and inconvenience to the public for the failure of the contractor to complete the work for the use of the traveling public; and, second, the expense of administration for overhead and inspection during the extra time used by the contractor.

The district engineer may recommend that after the pavement is opened for traffic and after the contract time has all been used, all time charged thereafter may be remitted with the exception of the equivalent of the inspectional charges. If such recommendations are approved the charge shall be the actual inspectional charges during such period, based on calendar days regardless of working days that were consumed.

If any special cases arise that are not covered by the above conditions the district engineer is instructed to submit the facts to the main office for decision.

SUPER-SAFETY PROTECTION FOR HUDSON TUNNEL USERS

An electrical protective system, which will insure super-safety to the Holland Vehicular Tunnel between New York and New Jersey, is in the process of installation and, according to R. E. Bedworth, Westinghouse engineer, an order totaling a half a million dollars for necessary equipment has been awarded by Fishback & Moore, electrical contractors, to the Westinghouse Electric and Manufacturing Company.

The new vehicular tunnel is to have the most elaborate provisions for safety of its users of any place in the world. The Tunnel Commission's engineers have worked out a system for protecting motorists and methods for protecting the protective system that surpass anything of this kind that has ever been designed.

With regard to the lights that illuminate the tunnel every other lamp will be supplied with power originating in New York and the remainder with power from New Jersey; and in addition, each group will have three independent sources of power supply. In other words, each light and each ventilating unit may be supplied with power from any one of six independent sources. It will, in fact, be necessary for four power houses to be destroyed before power for the ventilation and lamps will fail. In addition, the traffic signal lights will be automatically fed from an emergency storage battery in case all other power should fail.

Three kinds of traffic signals will direct the motorists using the tunnel: Green for 'go ahead'; red for 'stop' and a special 'stop-engine' signal. These lights will be spaced 240 ft. apart. Traffic officers every 480 ft. will patrol the tunnel and for each there will be a traffic light control station and a telephone.

Normally, only the green lights will show and the traffic will flow along as rapidly as possible. Should trouble arise, such as a collision or a car-fire, the nearest officer will promptly press a button, and then all traffic lights up to the point of accident will show red, thereby stopping on-coming traffic. The remaining lights will stay green, permitting the traffic ahead to clear itself. A hose and a chemical fire extinguisher every 120 ft. and a sand box every 240 ft. provide means for promptly controlling most fires, and tests have proved that the ventilating equipment will remove the fumes without danger to the occupants of the tunnel.

If the situation is such that it cannot be cleared up locally, the officer presses another button and summons one of the fire-and-wrecking trucks which are to be maintained in constant readiness at both ends of the tunnel. This truck will come in against the moving traffic, and as soon as it starts, a special yellow signal is flashed along the tunnel, notifying the officers of its approach and enabling them to clear the road for it.

When traffic can start again, the officers in charge will press a third button and the red lights will change to green. If in the meantime, however, an officer back along the line has for any reason pushed his stop button, the 'go-ahead' lights will light only up to that point, the remaining lights staying red until changed at the proper station. Thus, the clearing of traffic at one place will not start traffic where trouble still exists.

All this the motorist will see. What he will not see is a room in the administration building at the New York end where a board carrying 926 pilot lights will inform a central operator of every thing going on within the tunnel and will enable him to take full charge of any situation at any time.

All changes in the traffic lights made by the traffic officers will be registered in the control room, and, if necessary, the central operator himself will be able to stop traffic at any desired point. When this happens, the traffic officers in the tunnel cannot reset the signals, but this can only be done by the central operator.

The pilot-light board in the control room will show, in addition to the position of the traffic lights, definite signals indicating the status and speed of every piece of ventilating apparatus and the conditions of every circuit serving the tunnel. If a motor fails, a fan breaks down, a circuit goes dead, or a short

circuit develops anywhere, a bell will ring, and a bright light, indicating the location and character of the trouble, will appear. The operator can stop the bell, but the light will continue bright until the trouble is corrected. When everything is in good order, the pilot lights will burn dim, so that a bright light instantly attracts attention and calls for an investigation.

The 83 ventilating fans, located in the four ventilating-shaft buildings serving the tunnels, will be under the control of this central operator. He will vary the air supply in accordance with conditions within the tubes, providing at all times an excess of pure air. The operator will have sensitive instruments available which will show definitely the exact amounts of impure air. This will enable him to make a positive test of the purity of the air and detect small quantities of foul gases before they reach such proportions that they would be noticed in the tunnel. Six independent circuits will provide the power for these fans and duplicate equipment will always be in readiness to take the place of any fan that goes out of commission. But if in spite of all these precautions the fans should fail and the air in the tunnel becomes too heavily charged with exhaust vapors, the 'stop engine' signal will be flashed, thereby preventing further contamination of the air until the ventilating equipment is put into operation again.

As an instance of the refinement of this system, the 'stop-engine' signal cannot be displayed unless the red 'stop' lights are first lit, thereby preventing careless drivers from colliding with those who have promptly stopped their engines.

Should anything go wrong in the central control room, the fans can be controlled independently in the shaft buildings where they are located. Normally the power supply for the fans and control equipment will be split 50-50 between New York and New Jersey, but any piece of apparatus can be supplied from any source the operator desires, and all switch gear is to be so interlocked that it is impossible to make a wrong connection.

This system is based upon the supervisory control system developed by the Westinghouse Company for central power stations and railroads, but it has been modified and extended to meet the special conditions of the tunnel by the Tunnel Commission's engineers assisted by the engineers of the Westinghouse Company. It is notable not only for the completeness of the protection it affords but also for the high degree of simplicity of its wiring and arrangement. This, in fact, has been one of the standard requirements of the tunnel engineers, who would approve no lay-out which appeared so complicated as to endanger reliability.

The tunnel will be illuminated by lamps. spaced every 20 ft., except at the entrances, where they are spaced every 10 ft. to help in counter-acting daylight. Each lamp is placed in an enamelled reflector, set into the wall, and screened with a special frosted glass panel—a combination selected after many experiments by the Westinghouse Lamp Company to secure well diffused illumination and prevent glare.

The tunnel will be finished and opened to traffic early in the summer of 1927.

"BLACK BASE" AND ITS PLACE IN STANDARD SPECIFICATIONS

By Hugh W. Skidmore, President, Chicago Paving Laboratory, 536 Lake Shore Drive, Chicago

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., November 8-12, 1926.)

"Black Base" has acquired widespread recognition as a standard type of pavement foundation by reason of its long and honorable service record. There has been very little experimentation connected with the development of this type of foundation, especially for use under all types of asphaltic surfacing. Its use in this country dates back to the earliest days of asphalt pavement of the hot mix type, and its service record covers the same span of years. I do not believe anyone dare attempt to predict the probable expectancy of a well-built asphaltic concrete base. If it is allowed to function undisturbed by excavations, etc., it appears to possess almost interminable life.

Frequently you will see reference to a very old piece of "Black Base" that has been opened for some reason or other, and invariably you will note that its condition is excellent, showing no ill results from contact with earth moisture, frost and similar destructive elements.

The present extensive popularity of bituminous foundation is in no small measure due to its great adaptability to almost any conceivable local condition which may offer real difficulties toward the employment of any other distinctly

different type. Witness its use in widening and resurfacing old roads and pavements of all kinds, gravel, broken stone, waterbound and bituminous macadam, brick block and Portland cement concrete. Likewise, by virtue of this great latitude of application "Black Base" construction is rapily increasing—indeed, much more rapidly than most of us realize until we have looked into the matter to some extent. In short, engineers have not been slow to recognize its high merit once their attention has been directed to it.

Notwithstanding the efforts of a few of us to extol its virtues, "Black Base" construction has not received the publicity it deserves, and that much less meritorious types have received. There are hundreds of most admirable examples of this type of foundation which are practically unknown except to those who actually attend their construction—possibly even forgotten by them. But in spite of lack of advertising of this most excellent form of pavement construction, it is showing a remarkable yearly increase throughout the country. There are very few, if any, states which do not have at least a few excellent examples, and in some localities the yardage is very extensive indeed. Perhaps it is best that its development has resulted from the sheer merit of the product. It will be all the more secure, having so evolved.

It will be impossible to attempt to discuss in detail here the almost innumerable examples of "Black Base" throughout the country. But in order to indicate what is being done in a few localities, mention will be made of the projects which were personally inspected during the course of the past summer.

Before proceeding to the consideration of pavements actually examined we must acknowledge the vast yardage of this type in our most western states. This yardage, which is far into the millions. is by no means dormant, but is increasing by added millions of yards each year. In 1923 California alone had over 2,000,000 sq. yds. of "Black Base" pavement over ten years old. The City of Denver has been building "Black Base" to the tune of about a half million square yards per year during the past few seasons. Likewise, in the south and some of the southwestern states, there is considerable yardage including numerous projects with lime-rock asphalt surfaces and also many examples of the same type of rock asphalt employed in the base.

Michigan State Highways

The State Highway Department of Michigan during the past three construction seasons, has been engaged in an extensive program of "Black Base" stone-filled sheet asphalt paving over old graveled highways. During the season just passed, the state has operated two railroad plants on this work in addition to some similar construction by contract. In all, about 50 miles of such pavement will be laid on trunk highways during 1926, with a much larger program outlined for next year.

The pavement which has been laid is most excellent both as to design and execution. The old gravel roadways are bladed and roughly trued up and prime-coated with hot bitumen in advance of laying the "Black Base," drainage structures being first provided as on other paving projects. The thickness of Black Base varies in accord with the contour of the old roadbed, but has a minimum depth of about 2½ ins. and a maximum of about 5 ins. where the old gravel is quite thin and requires reinforcement. The base is laid 20 ft. in width and the top 18 ft. wide and 2½ ins. thick. Bank-run gravel of quite uniform grading is used in the base course which shows the following typical composition:

A. C.	5.6%
Gravel	94.4%

The gravel supply is controlled as to ratio of sand to coarse aggregate, and the appearance of newly laid sections of base, which were inspected, indicate that these proportions are maintained quite satisfactorily.

The top mixture is of the well-known stone-filled sheet type of the following typical analysis:

Bitumen	9.4%
Filler passing 200-mesh	13.7
Sand passing 80-mesh	17.4
Sand passing 40-mesh	27.2
Sand passing 10-mesh	9.5
Stone 4-mesh	6.2
Stone passing 2-mesh	13.4
Stone passing ¾-mesh	3.2

Inspection of all the work laid during the past three seasons shows no defects of any kind. Indeed, one can not refrain from remarking these excellent roads when driving over Michigan's trunk highways.

While we are in Michigan, we mention in passing that the City of Grand Rapids is laying from 50,000 to 100,000 sq. yds. of "Black Base" per year. These pavements employ a 4½ in. "Black Base" with 1½ in. top and they are costing less than

similar wearing surfaces laid on rigid base.

Passaic, and Paterson, New Jersey

In these two cities are to be found numerous examples of "Black Base" pavement from 3 to 5 years old. This type of foundations seems to have developed in Passaic some years ago, due to a desire to speed up construction which was originally intended to be standard 3-in. sheet asphalt on 6-in. Portland cement concrete base. The Contractor (Union Building and Construction Company) suggested substituting 7½-in. "Black Base" and 1½-in. sheet top in order to permit the use of important thoroughfares several weeks sooner than would have been possible had Portland cement concrete been used, thus making good use of another one of the many advantages of "Black Base." Imagine, if you will, how much valuable time (and time is money these days) can be lost in waiting for Portland cement concrete to cure. In some instances, say in new subdivisions, this might not be such a serious item but in the case of important streets in a big city it becomes a very important consideration.

No doubt the 7½-in. base is somewhat excessive, at least in most cases in these cities, but one can readily understand how it came into use, since the contractor agreed to build for the same price, the same total thickness of an all-asphalt pavement as was provided for usual 6-in. Portland cement concrete plus 1½ ins. of binder and 1½ ins. of sheet topping. All of the work in Passaic and some of that in Paterson has followed this original plan as to total depth of pavement. In Paterson, Madison Avenue between Main Street and the Erie Railroad was laid in 1923 using 4-in. "Black Base" and 2 ins. of topping, while Ellison Street, adjoining the City Hall and carrying very heavy traffic, was laid the same year using a 5-in. base and 3-in. top. Numerous Railroad crossings in these cities have been paved with "Black Base" and sheet top, with the utmost success. There has been no maintenance cost on any of the "Black Base" work; in fact the City Engineer of Passaic, Mr. Jas. E. Earl, stated that they have been able to forget about these pavements.

The composition of the base mixture is:

Bitumen	4.5%
Sand	17.5
Stone passing 1½ in.	78.0

(This mixture was laid in two courses.)

Mercer County (Trenton) New Jersey

Mr. H. F. Harris, County Engineer of Mercer County, told us in detail about his Black Base work at our Louisville meeting two years ago. In July of this year I had the pleasure of inspecting several miles of these pavements with Mr. Harris, and can vouch for the fact that they are giving service of the highest type. All of these pavements are on heavy traffic arteries, either within the city of Trenton or immediately adjacent thereto.

The usual construction is 6 ins. of base laid in two courses of regular binder composition, that is, employing comparatively small coarse aggregate, with regulation sheet asphalt top. Hamilton Ave. is an exception to this procedure as the base was laid 3 to 4 ins. in depth over an old macadam roadway.

While we are discussing New Jersey work, mention is also made of quite a yardage of Black Base of the penetration type in Rutherford, all of which is giving an excellent account of itself.

Richmond, Va.

Two years ago, the Richmond-Seven Pines Road was built under the direction of the Virginia State Highway Department. This pavement consists of 4 ins. of base and 1½ ins. of sheet asphalt top. It would be difficult to imagine any pavement being built under any more adverse conditions. The soil is yellow clay which retains its moisture for extremely long periods. There is practically no side drainage away from the pavement and, to cap the climax, it rained almost constantly during the early part of the construction work. In fact, the soil became so saturated and unstable that the engineers ordered the work stopped for a period of six weeks during its progress. It is doubtful if a poorer location could have been chosen for any kind of paving construction, especially without first correcting the subgrade troubles.

Despite this poor start, the work looks good. There have been a few areas along the edge which have depressed under traffic in the soft earth and these will require some maintenance. But on the whole, the job looks quite satisfactory considering the extremely poor conditions attending its construction.

The State Highway officials realize the disadvantage the road is under and consider that it has made a remarkable showing.

Pittsburgh, Pa.

You will recall the enthusiasm of Mr. J. D. Strain as he told us about Pitts-

burgh's Black Base at Detroit last fall. I can assure you that if you care to visit his work, some of which is nine to ten years old, you will agree that he has ample reason for being a strong advocate of this type of construction. As his guest, I inspected many miles of such pavement this past summer and I confess that I have never seen better. The yardage of such pavement in Pittsburgh runs well into the hundreds of thousands. He tells me that none of it has cost the city a cent of maintenance and most of this work has been done on heavy traffic streets in the downtown district and on boulevards carrying dense traffic.

Much of the Black Base has been laid directly upon the native subgrade, while some, such as Beachwood Blvd., was laid over old roadways and hence varies in depth from 4 to 7 ins. In some cases such as Smithfield and Diamond Streets (on earth subgrade), which carry extremely dense, heavy traffic, the base was laid 10 to 12 ins. thick. Mr. Strain is justly proud of the fact that the entire block in front of the P. & L. E. Station on Smithfield Street was completed, including excavation, base and top, during the working hours on a certain Sunday in 1921. Again we see the time element a very important factor. Such a fact could not have been accomplished by any other form of construction.

Author's Practice

During the season just closing, several Black Base projects have been laid under our own supervision. Mention of these will show a few of the many ways in which Black Base may be utilized to advantage in accomplishing a very definite purpose. In Hennipin County, adjacent to the City of Minneapolis, a section of old wornout Portland cement concrete highway pavement on Minnetonka Boulevard was widened by means of Black Base and then the whole covered with a minimum depth of 1½ ins. binder, followed by 2 ins. of coarse aggregate asphaltic concrete.

At Kohler, Wisconsin a Portland cement concrete pavement was widened by constructing along side thereof a strip of Black Base 4½ ins. thick with a 1½ in. sheet top.

In St. Joseph County (South Bend), Indiana, the Edwardsburg Road, which consisted of a narrow gravel roadway, was widened out last year by means of a waterbound macadam and this summer the whole was covered with Black Base and sheet asphalt top. In some respects the work was quite similar to that being done in Michigan, especially with respect to laying the base 2 ft. wider than the top, thus providing reinforcement of the edge against possible lateral displacement. This is considered very effective and economical treatment of the edge, which generally requires some sort of special design to take care of the thrust of traffic along the outer edge of narrow pavements (18 ft. being classed as narrow in these days of super-highways).

During 1924 and 1925 about 100,000 sq. yds. of 4½-in. Black Base with 1½-in. sheet top was laid on native clay and loam subgrade in Quincy, Illinois, under our supervision. The base mixture on this work was extremely dense, by virtue of using a well-graded, crushed rock, coarse aggregate, from 2½ ins. down, in size. In every instance this base was laid in one course directly upon the natural subgrade and in some cases the nature of the soil made construction difficult in wet weather, but perhaps no more so than would have been the case with any other type of base, except possibly in the Aldo Boulevard district, which had formerly been a nursery and the soil was "made" for this purpose. It was so sponge-like that some hardship was experienced in two blocks of pavement owing to the difficulty of rolling the base and top on the quaky soil. In this particular case the unstable subgrade should have been covered with a layer of gravel or broken stone, but under the Illinois law governing Special Assessment work, it is impossible to introduce an extra of this kind without endangering the legality of the project. Once the pavement was laid however, no further trouble developed.

In connection with one of the pavements laid in 1924, viz., East Broadway, Black Base was chosen in preference to a rigid base because a sewer had just been laid down the center of the street, and since the soil was clay, it was almost certain some settlement would occur. The City Engineer (W. P. Bushnell) felt that if such settlement did take place, repairs to a Black Base pavement would be much simpler than with Portland cement concrete, as the bituminous concrete would eventually follow the subgrade, and a surface patch in the topping would restore the uniformity of contour. A few such areas did subside very slightly. These Quincy pavements, including grading, cost from $2.25 to $2.55 per sq. yd., whereas, Portland cement concrete pavements laid by the same contractor the same year, cost $2,62.

Another example of deliberately taking advantage of this same virtue of flexible base was in the case of the approach to a bridge on Nelson Park Road (East Wood Street) at Decatur, Illinois, in 1923. Black Base was selected for paving the bridge approach over a heavy fill (which was known to be still settling), although the remainder of the project leading to the approach employed a Portland cement concrete base. Heavy rains in the fall and spring following construction caused under-cutting at the edges and the pavement followed the subgrade down. These depressions were removed by simply applying new mixture to the surface in the usual way.

Thus it will be seen that contrary to first thought, the fact that Black Base does maintain contact with the subgrade may very well be one of its strongest features. If the usual rigid base had been used in these cases, the entire depth of slab, as well as the surfacing, would have required replacement on account of certain rupture of base due to settlement of subgrade.

During the same year, 1923, the Brush College Road, just outside the City of Decatur, Illinois, was paved with 1½-in. sheet on 5½-in. Black Base. Since this project has been previously described in detail, only mention is made now that after three years of service, not a single defect of even the most trivial nature can be found. Notwithstanding the fact that at least one well-known highway engineer said at the time that this experiment on Illinois black soil would fail, the pavement bears every possible evidence of a long and economical service period ahead. Indeed, observation of this particular piece of road has lead the Decatur Park Board to select Black Base for paving the Park drives.

Black Base, or better, bituminous concrete foundation for pavements, has established itself in the minds of many engineers and public officials. As soon as the average individual sees how it can be applied to meet the widely varying conditions as to subgrade, climate and rehabilitation of old worn-out pavements, he can readily appreciate its value. No other form of base can be so readily adapted to almost any conceivable local condition. It is the best known medium for resurfacing old brick and block pavements, likewise old worn-out gravel and macadam roadways, to say nothing of the constantly increasing yardage of worn-out Portland cement concrete pavements. Indeed, many engineers design Portland cement concrete pavements with curb heights suitable for the application of an asphalt top when the concrete shall have become cracked and uneven, as it surely will, so that it no longer can be used as a traffic floor.

Black Base began as one of the very earliest types of foundation for asphalt surfaces. Portland cement came upon the market as a cheaper material and the attention of engineers throughout the country was directed to the development of this type of rigid base and pavement, for the moment forgetting its predecessor, Black Base. Then asphalt became cheaper through the great development of the petroleum industry, and simultaneously the cost of Portland cement went up, so that to-day, in most localities, equal thickness of pavement of the Black Base type, regardless of the type of surfacing, will cost no more, and usually less, than Portland cement concrete. This is by no means an idle statement but is the result of very careful observation and inquiry among contractors in the paving business throughout the country.

Black Base construction is not experimental as is the case with rigid base. It is not doomed to certain inherent defects that to date are practically impossible of remedy, as is the case with Portland cement concrete, due to moisture and temperature variations. Its dedevelopment has been sound and logical and when reasonably good engineering judgment is used in design and equally good construction methods are provided by the contractor certain success is bound to follow. This does not mean it is entirely "fool-proof." It is not, but its use is attended with less hazard and provides greater economy than any other known type of pavement foundation to date.

Its use is not confined to bituminous surfacing. All forms of brick and block may be used with greater insurance of success than attends these same types laid on rigid base.

Frequent reference has been made to Black Base laid in Washington, D. C., about half a century ago and still in service. Omaha, Nebraska, laid 4½-in. Black Base with 1½-in. top in the years between 1889 and 1893 to the amount of more than 100,000 sq. yds. In 1924 these pavements were still in highly serviceable condition, only 2,134 sq. yds. having received new top during a life of 31 to 35 years. Thus the longevity of Black Base is thoroughly established. And when we add to this highly important

feature its low maintenance cost, low first cost and versatility of application we have included all of the major considerations affecting the selection of a desirable pavement structure. And thus will be seen the many sound reasons why Black Base has become firmly established as a standard type of pavement foundation.

IMPRESSIONS OF HIGHWAYS IN FIVE STATES

By J. F. Seiler, Bridge Engineer, Wyoming State Highway Department, Cheyenne, Wyoming

(From "Wyoming Roads" for November, 1926).

The writer recently had the opportunity of driving from Cheyenne, Wyoming, to a certain city in Indiana, and the thought occurred that there were a number of facts disclosed which would be of interest to Wyoming people. No doubt many of our people have taken this or similar trips, but it is frequently the case that the sharp comparisons made between our highways and those of other states by one intimately interested in Highway work are omitted by the so-called lay person on a pleasure trip.

On this trip the states traversed after leaving Wyoming were, Nebraska, Kansas, Missouri, Illinois and Indiana. The route taken was the Lincoln Highway, U. S. No. 30 to Grand Island, thence to Lincoln, Neb., thence to Troy, Kansas, via various State and Federal routes. At Troy, Kansas, which is near the Missouri line, the balance of the trip via Kansas City, Mo., St. Louis and Vincennes, Indiana, to destination was entirely on concrete pavement, with the exception of very short stretches of brick or macadam. At Troy, Kansas, a very nice pavement, with nearly all railroad crossings separated, takes one to St. Joseph, Mo., where the Missouri river is crossed on what is apparently a railroad bridge, the sides extended to accommodate vehicular traffic. For this service a toll charge of 40c is made, presumably 10c per person, with no doubt a minimum charge of 25c. From St. Joseph, which is a bustling city of about 100,000 population, a splendid pavement takes one to Kansas City, a distance of 60 miles. From Kansas City to St. Louis, over U. S. Route No. 40, one finds a perfect boulevard of a length of 263 miles, designed for comfort, safety and speed. The writer would say that here is the finest continuous extent of pavement in the world, without any question. More will be said about this splendid arterial highway in what follows. Crossing the Queen of Rivers, the Mississippi at St. Louis, the trip extends on to Vincennes, Ind., via State Route No. 15, through Illinois entirely over concrete, with a few miles of brick near Mt. Vernon. It should be said here that a more direct route, and all paved, too, could be taken to Vincennes, Ind., from St. Louis, but at Mt. Carmel, Ill., our party was forced north due to the swollen condition of the Wabash River which had put the ferries out of business. However, a crossing of the Wabash was effected somewhere south of Vincennes, and a winding road of gravel, narrow but good, took the party finally to U. S. Route No. 41, being the Dixie "Bee" line, so-called in the local parlance of the Hoosiers hereabouts. A distance of about 40 miles on this route, all concrete, and ranking right along with Missouri's famous highway above referred to, takes us to Evansville, Indiana, the destination, a city of over 100,000 population and situated near the confluence of the Ohio and Wabash Rivers.

This in brief gives the outline of the route, much as one reads the condensed through time tables of a transcontinental railroad. An effort will now be made to give some of the impressions received and observations made on the various types of road construction, methods of construction character of maintenance, and bridge construction, separation of railroad grade crossings, location and alignment, drainage and other conditions affecting highway construction.

At the time of leaving Cheyenne after a period of wet weather, and over an earth road to the Nebraska line, one was pleasantly surprised to travel on splendidly maintained highways in Nebraska. Each day literally dozens of the so-called "One Man" maintainer units were passed, each busily traveling up and down, keeping the road surface smooth. These maintainer units were all powered with Fordson tractors, each carrying rather a long blade, about twelve feet, the writer would say. No other kind of maintenance outfit was seen on Nebraska highways.

The writer was especially impressed with the wonderful gravel surfaced roads in this state. Everywhere uniform, seemingly constructed of the same kind of gravel, wide and exceptionally smooth, and always well maintained, both as to surface and drainage. It was noticed on these highways that a windrow of gravel was placed along one edge of the

roadway, and upon inquiry at the offices of the Highway department, it was learned that, in the construction of these roads, the contractor's work was completed after the grading was done and the specified amount of gravel was placed in a windrow, along one side (on the shoulder) of the road. Thereupon the maintenance department takes over the road, and spreads the gravel in thin layers across the roadway and continues as traffic compacts the surface. We noticed in all cases that the gravel was fine, probably the larger proportion passing through a $\frac{3}{8}$ in. screen, and nothing larger than $\frac{3}{4}$ in. This fact we believe is largely responsible for the perfectly smooth surface obtained. In travelling over 600 miles across the state we failed to see any road corrugations, except in one or two places. For example in coming into Lincoln from the north, over a very heavily travelled gravel road, there was not the slightest indication of road corrugation. In traveling over one project under construction, we noted that considerable loose earth was left on the newly made grade, and gravel was bladed right into this earth. The reason for this, was of course, because the gravel used was river material and carried no binder. with the surfacing gravel carrying such a large proportion of "fines," it was rather surprising to note the entire lack of an excess of fine material on the road surface. There was, in all cases, just enough of this material—a fine film—to keep holes and corrugations from forming, at the same time leaving a surface almost like pavement to travel upon. The writer was deeply impressed with Nebraska's surfaced roads, and would like very much to see some of their methods applied to construction of our roads, where feasible. Nebraska, however, has taken a step backward in constructing many of their highways particularly the eastern part of the state, on section lines, or lines parallel to them. This causes much inconvenience and delay to travellers, who are obliged every few miles to slow down and turn right angles. Needless to say, there is a waste of power which costs more to travel, aside from the loss of time.

To any one who is familiar with the soil of Eastern Nebraska, it is needless to point out that roads, unless surfaced in this part of the state are practically impassable in wet weather, as the writer learned, when upon leaving Lincoln for Nebraska City, we were obliged to turn back due to a heavy rain which had transformed unsurfaced portions of this road into a sea of deep mud. Proceeding south via Beatrice, we travelled without difficulty to Falls City, and the Nebraska line on splendid gravel roads, going however, some thirty miles or so out of our way.

Nebraska has made wonderful progress in the construction of its State Highway System. One is led without question to this conclusion, when one considers the vast mileage of their splendid roads which have been surfaced and serve so adequately as "all weather" roads. Yet one finds, as always, criticism of the State Highway Department. For example, in the village of Auburn, where we purchased gasoline for 17c per gallon (the cheapest of any place on the whole trip), the attendant explained that on account of a gasoline war the price was 15c, the 2c being added for road tax. As a parting shot he added that the State Highway Commission was so slow getting their roads built, he guessed "they would never get through even with the 2c gasoline tax." And yet Auburn is located on a wonderful gravel road from Omaha all the way to the line between Nebraska and Kansas.

We passed through but a corner of Kansas, making a total of less than 60 miles in the state. Approximately 14 of this was pavement, between Troy and St. Joseph, Mo., the balance was just plain mud. Unfortunately the rainy weather had transformed Kansas roads into almost impassable barriers, which could only be negotiated with the greatest difficulty and loss of time. However, they were well graded, and if we could only have had a bit of sunshine, they would have dried quickly, but is was not to be thus. Under the circumstances we were unable to see any maintenance work, nor scarcely any construction features, because close attention to the middle of the road was always necessary. Our frank opinion of Kansas conditions is that this state apparently has a very large investment in graded earth roads which are nearly useless at frequent periods. For example in Eastern Kansas, this year, there has been rain nearly incessantly since July or early August. How much it has cost the motor vehicle owners of that portion of the state would be difficult to estimate, but certainly it is a huge figure. We noticed for example, that even in the condition the roads were, there was nearly as much traffic, if not fully as much, as on our Yellowstone route north out of Cheyenne, in the mid-

dle of summer. We knew it must be unthinkable for anyone to travel those roads except under direst necessity.

No doubt Kansas has its own problems, political and otherwise to solve, in connection with its Highway Construction, but it does seem to the casual observer, that the Commission of that state could better afford to complete at least portions, and greater portions than they have already done, of their highway system as they go along, by surfacing, and thus obtain highways which would be all weather roads.

One finds the greatest transformation in the state of Missouri. Here, as rapidly as it can possibly be done, the main routes are all being surfaced with concrete or other hard material. In traveling from St. Joe to Kansas City, 60 miles, and from Kansas City to St. Louis 263 miles, we were on concrete all the way (except for a short detour at Columbia) until a short stretch of brick was encountered entering the city of St. Louis. And Missouri has done the job right, for aside from the wonderfully smooth surface of the pavement, all center lines marked, section lines and right angle turns have been abandoned, and one could not but delight in the perfect alignment, easy curves and grades. Although it is reported Missouri has a speed limit of 25 miles per hour, apparently no one heeds it, as cars travel along at high speed and all goes merrily on. Going out of Kansas City at really moderate speed for such a fine artery of travel, we would find ourselves 40 miles further on our way at the end of each hour. This no doubt accounts for the immense amount of traffic that the pavement carries or accommodates, and yet it was often remarked how relatively small an amount of traffic there seemed to be to hinder our progress. The writer would judge that this highway, particularly near Kansas City, carries far more traffic than the Denver-Greeley road, yet with Colorado's vicious speed control that highway is always clogged and cannot be comfortably negotiated at over 25 miles per hour average speed. One of the most important and gratifying features of Missouri's main highways, is the fact that they have located them so as to pass around all the villages and town or cities. In nearly all cases one has to turn off the slab to go into a town. In going from one end of the state to the other, which can be easily done in less than eight hours, one passes only through the cities of Boone (where the Missouri River is crossed) and Columbia, the latter being the seat of the State University. St. Charles, near St. Louis, is of course on the slab, and here there is another crossing of the Missouri on a toll bridge, but St. Charles is practically at St. Louis. From this point one proceeds as if on a city pavement.

On this marvellous highway, one naturally sees no maintenance, as we usually think of it. Occasionally where the pavement on a high fill has settled some, there is repair work going on. That measures essentially, the extent of maintenance. Ditches are well constructed and kept clean, and the wide shoulders, about 5 ft. on each side of the slab are sown to grass and thus are virtually self maintained. Concrete gutters constructed through hills where there is some grade, say over 3% or 4% carry off water efficiently and are self-cleaning. In connection with the pavement itself, the drainage structures are all of good substantial design, so far as one might judge from passing over, and skew structures are very numerous, showing that absolutely nothing was sacrificed in the way of alignment to obtain cheaper structures. Highway facilities may be built as substantially and good as this route from Kansas City to St. Louis, but none could be better, unless constructed along the lines of the so-called "Super-Highway"—but the present construction will fit every need admirably, for years to come. Sharp curves on this highway, one might say do not exist, however in some cases, the slab has been widened with the crescent where a curve exceeds a certain degree. One cannot but extend to the Highway Commission of Missouri, heartiest congratulations on the splendid work they have done and for the wisdom and foresight exercised in every detail of the planning and construction and completion of this great highway.

Passing through St. Louis, and crossing the Mississippi, one is now on Illinois soil, and as before, the pavement slab ever stretches out as far as the eye can reach. Alignment is excellent and grades easy, the quality of the concrete is as good as in Missouri, but Illinois has made the fatal mistake of locating their highways through the towns, at least through very numerous ones. This means delay and despair in many instances where every few miles one is confronted with the "pronunciamento" "speed limit 12 miles—ENFORCED." Nevertheless it is wonderful to travel these splendid highways, in rain or shine with equal

ease and with no danger of slipping or skidding. It was noticed in Illinois that frequent large signs posted along the route states that the pavement was constructed from Auto Fees. Due to the valuable farming lands everywhere adjacent to the pavement, this no doubt is effective in reminding the corn farmers that it was not their tax money which was used for that purpose, and allays much criticism.

Indiana has followed much the same plan as has Missouri in avoiding centers of population with the main highways. In an old settled state like Indiana, literally dotted with towns and villages, it is remarkable that in driving from Vincessnes to Evansville, a distance of 57 miles, one should pass through but one town, Princeton. The writer should judge that Indiana construction ranks equal with Missouri, with a point in Indiana's favor on its bridge work. Nowhere will one find structures superior to those in Indiana—economical, but well proportioned, sturdy and showing all earmarks of good design and construction. Indiana's pavement is very smooth, laid apparently without construction joints either longitudinal or transverse, and center lines are marked only on curves. This latter feature is not so good as the plan of the universal center line. It is a great aid to traffic. As in Missouri and Illinois, the section line and right angle turns have been abandoned, with the result that Indiana highways, such as U. S. No. 41 at least, are efficient and fast arteries of travel.

Everywhere Highways were found to be splendidly marked. I think perhaps Nebraska and Missouri rank at the top, with their clear designations through cities, numerous signs and the neat little square marker set just below the main marker in case of turns, indicating "L" or "R" owing to the direction to be taken.

No Highway Engineer's education is complete without a motor trip throughout other states to get the various "slants" on the situation which such a pilgrimage affords. The writer would recommend that whole State Highway Commissions could take such trips, with great profit to the people of the state they represent. It is the only true method by which they may adequately evaluate the results of their own work, and apply to their own cases the benefits of the experience of others.

THE UTILITY CUSTOMER

By G. C. Staley, Chief Bookkeeper, Indianapolis Water Co., Indianapolis, Ind.

(Paper read at 1926 meeting of Indiana Section of American Water Works Association.)

In speaking of the users of utility service, it is very natural to term them consumers. However proper it may seem to speak of them as such, it seems that they are not merely consumers but are by right, real customers. Webster defines a customer as one who buys regularly from a store or a tradesman, and while a public utility may not be classed as a store or a tradesman, yet the consumer is a regular buyer and under this assumption he is a customer and entitled to all the consideration, courtesy and service which he would naturally expect to receive, and which would be gladly extended to him by the up-to-date merchant or tradesman.

In looking over the accounts of the utility customers, we find them generally divided into two groups—Industrial and Commercial. There is another division, which ordinarily is not mentioned, and which comprises customers from both the industrial and commercial. This division is made up of small stores, shops and the smaller manufacturing plants, and, while not producing a great amount of revenue, they are an important class of customers in themselves, due to their numbers, and also due to the fact that shop keepers and small merchants and manufacturing plants are in closer touch with neighborhood opinion than the industrial customer.

In looking over the industrial list, we find such customers as public utilities, large manufacturing plants, such as automobile factories, foundries, furniture factories, pharmaceutical manufacturing plants, and others who use a large volume of service. The commercial customers are the residences, apartment buildings, stores, public schools, churches and others who may not use a large amount of service, but whose demands are steady.

The amount of service required by an individual customer varies to a marked degree. This variation may be attributed to a number of reasons. For instance, take two similar automobile manufacturing plants, both located in the same city, with working conditions and demand for water practically the same. It may be found that one plant is using, and demanding, many times the amount used by the other, and, upon investigation, it

will be found that the plant using the smallest amount of water will have, in addition to its public water supply, private wells and its own pumping equipment. Underground leaks and general wastage of water are also factors to be considered in an industrial supply.

In dealing with the industrial customer, who maintains an auxiliary service such as deep wells, there are many times when utility officials can and should co-operate with the industry in the use of its auxiliary system. Whenever there exists a dual system of water supply, special attention must be given in order to safeguard the city's supply of pure water from a possible contamination. In such instances, the close co-operation of the water works officials and the customer becomes a public affair. The following notice was recently mailed to every customer of the Indianapolis Water Company and produced much favorable comment.

A PUBLIC WATER SUPPLY OF HIGH STANDARD

Twenty-two years ago this company established its laboratory for the control of the safety of the city's water supply, and since that time it has been continuously under the direction of Mr. Harry E. Jordan.

From the beginning this control was a daily affair, and not a random or occasional performance. Samples are collected every day from throughout the distribution system and observations are made hourly at the purification plant. During 1924, 12,000 samples passed the scrutiny of the laboratory staff.

In 1925 the United States Public Health Service adopted a new and higher standard of safety and purity for public water supplies. The laboratory records show that the Indianapolis water supply has for over five years more than met this new and higher standard.

The citizens of Indianapolis may rest assured that their water supply will be held as safe as every bit of modern knowledge and skill can make ti.

Indianapolis Water Company,
Indianapolis, Indiana.

I wish to emphasize the fact that, although a majority of the business between the utility and the industrial users is carried on by means of letter and telephone, the company should never lose sight of the value of personal contact and the feeling of friendship and helpfulness should be fostered on all occasions.

The commercial user it not a large user of service, his demand being steady with very little variation on account of business depressions or other conditions which might seriously affect the business of large concerns. We find that business dealings with the commercial customer are transacted generally by contact in the utility office.

The commercial customer comes to the utility office to have the service connected and also to learn the manner of using this service. There is always the first visit to have the water turned on, and the treatment received by the customer in the office of the utility company leaves a lasting impression. If the customer is treated courteously, and the service explained to him in a perfectly frank and friendly manner by the clerk with whom he is dealing, he will have a friendly feeling for the utility which will not be quickly set aside.

In a great many cases the customer, especially when he wants service connected at a residence or small store or shop, will first call the office of the utility, ascertain the location of the office, if he happens to be a newcomer to the city; ask the manner of paying bills and what advance payment or deposit is necessary in order to get the service connected. These questions are usually received by a telephone operator, sometimes being answered by the operator herself, other times being turned over to a telephone or contract clerk, who gives the desired information. If the information is given in a friendly manner and a pleasant voice, the customer feels that already he has established a line of common interest between himself and the utility, and that due to this common interest he has no hesitancy in coming to the utility office, mentioning the fact of his telephone conversation and asking what is further necessary to have service connected.

We now come to the important question of counter and telephone clerks. The use of women clerks at the public windows of a utility has been tried with varying success, but, in our case, we find that the customer prefers to deal with a man clerk instead of a woman, but if the customer is asked his reason for this, in a majority of cases he is unable to give a sound reason for his preference. It seems to be assumed by the customer who is desiring service, that if he can talk to some man, who apparently has the authority to order something done, that service will be given quicker and with more of a degree of assurance. Before leaving this question we wish to say that many public utilities are employing women cashiers, and what today may seem to be an innovation or fad, may tomorrow be found to be a sound business principle.

It is well to refer briefly to the qualifications of clerks placed at the windows for dealing with the public. These men should be of mature judgment, not necessarily old, with at least a high school education, and if possible should be college graduates. This clerk should be naturally adapted to this kind of work—one who is pleasing and friendly in his manner, who has a pleasant voice and yet can speak with a tone of certainty, and who shows by his actions that he is thoroughly familiar with the work he is trying to do. His personal appearance must be above reproach, and inasmuch as it is necessary that the window clerks do a certain amount of writing, figuring and calculating in the presence of the customer, he should be at least a fair penman and accurate in calculations.

It is also well to refer to the qualifications and duties of the telephone operator, for through the telephone, which is today one of the most important connections between individuals, we find that impressions are made, and whether good or bad, are retained, sometimes to the detriment of those concerned. Generally speaking, it is advisable to use a woman in this position, inasmuch as telephone companies, without exception, use women and girls as exchange operators and it is only natural when a customer calls for a public utility office which is equipped with a private switchboard, to expect to hear a lady's voice at the other end of the line. As I have said before, the first word spoken by the operator creates the first impression the customer has of the utility.

No one having imperfect hearing should be employed in this position, for there is nothing more exasperating to a prospective customer than to have to repeat several times because the operator cannot understand what the customer is saying. The telephone operator must have a world of patience, because when the signal light shows on her switchboard she has no way of knowing whether the call is going to be one requesting information, or an irate customer with real or fancied wrongs, who is bent upon upturning all civilization in order to secure what he thinks are his rights.

It is necessary that the telephone operator have knowledge of all of the duties of the different departments, and it is advisable that she know the personnel of each department, for in this way the different calls that come in can be transferred to the proper party without the inconvenience to the patron of shifting from one phone to another. Not all women, even though endowed with a pleasant voice, perfect hearing and patience, can become telephone switchboard operators. There is a peculiar adaptability of some women to this work, and when an operator is found who has these peculiar characteristics, a valuable asset is added which cannot be measured by her position on the salary roll.

In rendering a public service, it does not seem possible to satisfy everyone all the time. New equipment and machinery must be added to keep up with the constantly changing demands; personnel and office routine change. What was a satisfactory service last year brings a complaint and criticism this year. In our endeavor to remove the causes for these complaints and criticisms we are giving a more satisfactory service. Complaints made today are welcome, for we try to make them stepping stones to improve the service of tomorrow.

Most complaints are made in good faith. Others in the hope of having bills reduced, and in some cases, there is no apparent reason or cause for complaint.

We will first take up the causes of the usual inquiry or complaint. These causes may be few or many, and they may or may not be the fault of the utility company. In a majority of cases we believe that it will be found that the inquiry is the result of a lack of knowledge on the part of the customer properly to utilize the service at hand. Poor water pressure; discolored water; high water bills; complaints made because some neighbor is receiving service on a flat rate basis lower than some one else, or the complainant's bill may be higher than his neighbor's bill. All these, and many more, constitute the complaints and questions that must be settled diplomatically and to the best interests of the utility.

When the meter reader takes the reading of the meter and finds the consumption above the usual amount, he makes inquiry of some one at the premises as to any unusual use of water during the preceding month. If no reason for the increase is known, the meter reader at once makes an inspection of the fixtures and in practically all cases the trouble is found and the cause for complaint eliminated. The meter reader reports all such cases to the office and a postal notice is mailed that day to the customer, as follows:

INDIANAPOLIS WATER COMPANY
Indianapolis, Ind.....192.....

To the consumer:

Our meter reader reports that the meter

located at .....
registers.....cubic feet for the period
..... to .....
This is higher than the usual consumption and may be caused by defective plumbing, leaks or carelessness.

The probable cause of the high consumption as reported by the meter reader is .....

We would suggest that you investigate this matter.

Yours very truly,
F. C. JORDAN, Secretary.

During the month of January over 300 of these voluntary inspections were made by meter readers. In case the customer reports that his service is suspended, or cut off, immediate action should be taken to locate the trouble and apply whatever remedies are customary, and so notify the customer with a minimum amount of delay. When the customer comes into the office of the utility with a complaint, there should be a willingness shown on the part of the person to whom the complaint is made immediately to ascertain the justness of it. If it is found to be based on facts, and there is a justification, it should be speedily remedied. Any credit for overcharge should be immediately adjusted, and if payment has been made cash refund should be made. If, however, the complaint is found to be only fancied, the greatest tact and skill will be required on the part of the clerk in satisfying the customer.

It should not be thought that a complaining customer is a necessary evil, as it is only in this way that the shortcomings and deficiencies of service will be brought to light.

The company should keep a record of all complaints, the cause of the complaint and what was done to remedy the situation. In this way, a better and more satisfactory service can be furnished. To the customer who makes a complaint, it is very often a means of acquiring knowledge, and in the majority of the cases the customer profits to the extent that he does not again find it necessary to make the same complaint.

Office Arrangement for the Convenience of the Customer

The majority of modern and up-to-date business establishments such as stores, public offices, waiting stations, and other similar places, where it is necessary for the public to congregate for business purposes, have gone to a great expense for the comfort and convenience of their customers. Rest rooms, lounging chairs, writing desks and telephones have been installed for the conveniences of the customer, and for the same reason that these conveniences were installed for the customer of a retail store, the public utility should arrange its office for the convenience of those who come into the office for the purpose of transacting business.

Unused space in the office lobby may be used to good advantage for educational and advertising purposes. In our office at Indianapolis we have approximately 1,000 square feet of lobby space. This space has been utilized with the following exhibits. An aquarium containing gold fish, growing moss and shells; two lavatories, one of the old unsanitary kind with leaking faucets and the other a new and attractive type; an attractive and sanitary drinking fountain; three display meters, all properly connected up and one actually in service; one complete bath room outfit, consisting of shower, tub, lavatory and water closet. At appropriate places in the lobby we have on display large photographs of the pumping stations and equipment.

These exhibits are changed frequently and each month the customer who comes to the office will find something new.

We have a bulletin board placed in a conspicuous place, on which are posted items of interest to the customer, such as data relating to metered service, leaking fixtures, reports and comments of public service commissions, etc.

The utility office consists of two main departments. The Cashier's Department, for the payment of bills, and the Service Contract Department for making contracts for utility service and the furnishing of a medium of communication between the public and utility. The public windows should be located at the most convenient place in the office, making it unnecessary for the customer to climb a long flight of stairs, or use an elevator, for the purpose of getting to the proper room to pay bill or make a contract for service. The windows should be plainly marked so that any one entering the lobby of the office may see at a glance the different departments and make it unnecessary to inquire of some one as to which window they should go to pay their bill. There should always be an adequate number of windows to care for the people coming into the office, and each window should be manned by a sufficient number of clerks.

We find that of the number of individual customers handled in one utility office, the cashier's window handles many, many times the number of those handled by the aggregate of all other

windows. This may be explained by the fact that a large number of people prefer to call at the office and pay their bill and receive a receipt. The cashier and his assistants should be equipped with automatic money changers, cash registers and receipting devices in order that they make the change quickly and correctly that the lines of waiting customers may be served as soon as possible. Politeness, accuracy and speed are three of the most important of the qualifications of a utility cashier. In a number of cases, we find that bills for water service are all made payable on the same day of the month or quarter. This arrangement causes a great confusion and congestion in the office around this paying date.

We have overcome this by a spread of the paying dates over the entire month. About 1,500 bills are mailed out each working day. This eliminates the big days and has proven to be one of the most important factors of service for our customers. On our busiest days, a customer may come into the office and pay his bill in less than four minutes time.

Contract Window Service

Service given at the contract windows is equally as important as that of the cashier's window. The contract clerk must be thoroughly trained in his duties and have a natural ability to please the general public, and, at this point, I want to say again, that this position calls for the exercise of unusual diplomatic ability. The public coming into the office forms an opinion of the utility, not by what it afterwards receives, and not by the size of the building, but from the actual reception accorded it by the representatives who stand back of the contract and service windows.

We believe that, while all clerks should be thoroughly efficient and capable of answering any and all questions that may arise in the nature of their duties, there are certain lines that should be divided and assigned to different locations.

It seems advisable to have a window where duplicate bills may be secured; one window should be alotted to new service accounts and transfers, and, where plumbers are required to take out permits making reports on all connections and disconnections made, we find it very advisable that they be waited on at a window entirely removed from that of the general public, as their business is in no way connected with that of service to the public in general. There are arguments for both sides of this question, and excellent reasons may be given for a combination of duties at one or two large windows, or for the separation of the duties to different windows. We believe that with a division of work to the windows where it may be handled by a special clerk in this department, greater efficiency and more direct service to the individual may be given.

It is advisable in all public utility offices to have a floor man, or information clerk, located at a desk in the lobby, which desk may be seen at once by the customer upon entering the door. This information clerk, in case it is a man, should be neatly uniformed and of sufficient intelligence as to the business of the company to answer all ordinary questions pertaining to the service rendered. Care should be used in picking the type of man for this work. It is generally advisable to procure an older person, who has been with the company for some time and who is thoroughly familiar with the different duties of the different departments, as in this way a quicker service and better satisfaction can be given to the customer upon his first visit to the office.

The service bill is the all important factor in the relationship between the customer and the utility company, for it is through the bill that the customer's interest is drawn to the company once every month, or quarter, as the case may be. In the payment of these bills the attention of the customer is drawn directly to the company, and upon the receipt of the payment of these bills the very existence of the company depends. So, what could be more natural than the judging of a utility by the bill rendered. Bills for utility service should always be rendered in a prompt and business-like manner. In some instances the utility companies have their own carriers to deliver the bills; others turn them over to distributing agencies for delivery; in some cases, bills are delivered by the meter readers, but we find that quite a large majority are delivered by the medium of the United States Mail. It has been found, by an actual checking of the cost of delivery by distributing firms, to be approximately 2 cents per bill. This is about the same as the cost of delivery by mail under our present postal rates. After trying out the delivery of bills by distributing agencies and our own carriers, we have returned to the plan of delivery by United States Mail, which we find to be the most satisfactory plan. There is a difference of opinion, and in-

cidentally quite a difference in cost of delivery, as to the form of bill used. If the bill is made out on a United States Government postal card, it may be mailed for one cent. While, if made on any other form except the Government card, 2 cents is required for the delivery of the bill. If use is made of the Government postal card, it sometimes becomes necessary to eliminate certain essential parts of the bill, or to condense them in such a manner as to lose their effectiveness for clearness to the customer. As it is necessary that the bill be made out accurately as to date and amount, and in cases where the service sold is by meter measurement, it is necessary that the dates of meter readings, together with the readings and the consumption as shown on the meter, be shown upon the bills. We do not believe that it is advisable, where a sliding scale is used consisting of many different steps, to attempt to show the complete manner of figuring the bill through the different steps and calculations. All customers who desire it should be furnished with a schedule showing the entire rate, and, if they so desire, should be instructed how to apply the rate against the total consumption, as shown on their bills. With the proper education of the general public along this line, we believe that very little, if any, complaint will be made from this course.

Meter Readers and Inspectors

Meter readers and inspectors are the field representatives of the company. These men in the course of their duties come in contact at some time during the month or quarter with every customer using the utility service. When the meter reader enters the premises of the customer, he is not regarded by the customer as merely a meter reader, but is the direct representative of the utility company who has presented himself for the purpose of transacting a certain important business necessary between the user of the service and the company which furnishes it.

The identification of the meter reader and inspector must be made positive and unmistakable. There is no better way to accomplish this than that of a distinctive uniform which these men should be required to wear while on duty. By the use of uniforms, the customer is protected against impostors; the meter reader reads more meters because of quick recognition, and the company profits to no small degree through this investment.

The knowledge of a public utility and its employes is gained in a great number of cases only through the contact with the meter readers and inspectors. The meter is read; in a few days a bill comes in by mail; a check is attached to the bill and is returned to the utility office and, unless special occasion requires, it is taken for granted that the transaction is finished and that another period of time will elapse before any more thought is given to a service which stands at the instant command of the utility user.

In the same manner the clerks in the office are the main point of contact between those customers coming to the office to transact their business and the utility, so are the meter readers and inspectors the main point of contact between a larger number of customers and the public utility. If the meter reader shows by his manner and dress that he is a real gentlemen and that he is thoroughly conversant with his duties. If he is courteous, his clothes neat and clean; if he has at heart the duty of service to the customer as well as faithfully serving his employer, there need be no fear but that public opinion, which governs the prosperity of all utilities and business in general, will be found on the right side of the utility when occasion requires.

NEW FEATURE OF WATER PURIFICATION PRACTICE IN OHIO

By F. H. Waring, Chief Engineer, State Department of Health, Columbus, Ohio

(Paper read at 1926 meeting of American Water Works Association.)

The employment of water purification devices in a special way in water purification practice in Ohio will be discussed from two general standpoints. (1) A description of the research studies and experiences of several water purification and softening plants, and (2) a discussion of details and tendencies in the use of certain new water purification devices.

Pre-chlorination. Treatment of raw waters with chlorine is not a new procedure. There are, however, some new phases of this treatment that are being experimented with in Ohio. Studies are now being conducted at the Akron plant in the attempt to eliminate a troublesome gas forming organism that survives the usual filtration and chlorination treatment. The first part of the research involves the application of liquid chlorine in limited amount into the raw water

conduit at the impounding dam about one-half mile from the filtration plant. The chlorine applied will be limited to an amount such that no residual chlorine is present in the water entering the mixing chambers. The second phase of the research involves application of heavy amounts of chlorine at the initial point, followed by de-chlorination using sulphur dioxide at the mixing chambers. Results of these studies will not be available entirely until about October of this year.

Another research with chlorine application to raw water has been under way for almost a year, the work being started at Ironton and continued at Sandusky. The purpose of chlorine application in these instances is to relieve the extremely high bacterial load upon the ordinary purification process. The chlorine application experiments are being conducted in two ways in similar manner as that described in the Akron case; first, a mild treatment leaving no residual chlorine in the water passing to the coagulation basins; and second, heavy chlorination followed by de-chlorination before the water is coagulated. Ironton has a yearly average B. coli content of about 16,000 per 100 cc. with daily peaks as high as 100,000. Sandusky has considerably less pollution load, the yearly average being about 1,500 B. coli per 100 cc. with daily peaks of 10,000. The Ironton experiment has proved a failure on account of the presence of industrial wastes containing phenol in the Ohio River water, giving rise to chloro-phenol tastes that made the use of chlorine impossible in the water treatment; hence the activities have been transferred to Sandusky, where no phenol wastes are expected to interfere. From the bacterial standpoint the Ironton experience indicates that chlorine may be utilized to relieve the heavy pollution load and not interfere with subsequent processes, if no residual chlorine is left in the water coming to the coagulation basins.

Adjustment of pH Value for Optimum Coagulation. The operators in this state have studied the raw water conditions with a view to determining the optimum pH value for coagulation. Generally speaking not a great deal of difference seems to prevail in Ohio waters between the raw water pH value and its optimum for coagulation. However, two or three of the plants dealing with impounded reservoir or lake waters have felt that it was promising to have research along lines of reducing the pH value in the raw water before coagulating. E. E. Smith, superintendent of filtration at the Lima plant, has had in service for approximately one year devices to apply carbon dioxide gas to the raw water as it enters the filtration plant and prior to application of the coagulant. The treatment was begun as an experiment and has been so successful that the equipment first installed has been kept in regular use, and the city is now taking steps to provide permanent and more efficient equipment. The yearly average pH value of the raw water is about 8.0. The average optimum pH value for coagulation is found to be about 7.0. The carbon dioxide applied reduces the pH value about 0.3 and accomplishes a reduction in coagulant required of about 0.5 grain per gallon. The treatment has been limited to the above extent by reason of the undesirability of increasing the free carbon dioxide content of the filtered water, in order not to produce a condition of corrosive water. The plant is not adapted conveniently either for pumping the filtered water to aeration devices, or for secondary treatment with lime to correct the corrosive tendency of the final effluent; however, it is expected at a later date that this feature will be remedied in order that even greater savings may be obtained in coagulant application by first employing carbon dioxide gas to bring about the reduction in pH value of the raw water.

Double Coagulation. The term double coagulation has been applied to the use of two series operated coagulation basins with separate mixing chambers or devices to bring about coagulation in each basin. At the present time two Ohio filter plants have been rearranged to accomplish double coagulation (Portsmouth and Cincinnati); two plants were constructed new including this feature (Ironton and Toronto), and one plant is under construction utilizing series operated coagulation units (Norwalk).

There are two primary reasons for the tendency to use double coagulation in Ohio. (1) Ohio River carries a load of bacterial pollution that is too heavy for ordinary water purification processes employing one stage of coagulation; that is, the final effluent is made safe only because a great burden of purification rests upon the final process of chlorination. During the past two or three years industrial wastes containing phenol have seriously interferred with the use of chlorination for Ohio River water and hence it has become necessary to resort

to other means, at least for considerable intervals of time. An excellent discussion of Ohio River conditions in relation to limitations of water purification processes was presented by H. W. Streeter to the fourth annual meeting of the Ohio Conference on Water Purification. (2) A few reservoir waters in this state contain considerable amounts of color and have relatively low alkalinity. Double coagulation devices furnish excellent opportunity for coagulation of the color under these conditions, since any desired amount of alum may be applied alone in the first basin; lime may then be applied in the secondary basin to precipitate any free aluminum and to neutralize the corrosive condition of the water. The foregoing practice while new in this state has been copied from the experiences of the Wilmington, N. C. plant as reported by Catlett and Norcom.

Excess Lime Treatment. The term excess lime treatment has been given to the water treatment practice which includes the application of enough lime to the raw water to create a caustic alkalinity. Such is the practice at water softening installations for the purpose of bringing about the water softening reactions.

It was observed by C. P. Hoover, soon after the Columbus plant was placed in service, that the causticity thus obtained created a condition unfavorable to bacterial life, and that the effluent from the settling basins was sterile. At his suggestion Youngstown instituted the excess lime treatment for the badly polluted Mahoning River water used as a source of supply at the plant. That the treatment has been a success is demonstrated by the experience of the last few years. The raw water pollution load at Youngstown is probably the greatest of any water treatment plant in the country. The yearly average B. coli index exceeds 20,000 per 100 cc. and it is not possible to use chlorine at this plant because of interference by phenol bearing wastes. The final effluent during the past year has not shown a single positive presumptive B. coli test in any of the five 10 cc. portions tested daily. The safety of the water is entirely dependent therefore upon careful application of lime to the river water, and W. I. Van Arnum, superintendent of the Youngstown plant, deserves great credit for the careful conduct of this lime treatment.

Combination of Excess Lime, Double Coagulation, and Adjustment of Raw Water pH Value. Following the unsuccessful attempt at Ironton to relieve the bacterial load in Ohio River at that point, a change of treatment was made beginning in December, 1925. The experience of Youngstown and Lima has been made use of at Ironton in the following schedule: The plant has double coagulation facilities; accordingly, lime was applied to the primary basin in an amount to produce causticity, therefore sterilizing the supply. Alum was applied at the secondary basin to coagulate the turbid Ohio River water. It was noted that considerable alum was required if the influent water to the filters was to be kept in a condition to prevent carbonate scale forming on the sand grains as a result of the excess lime used. In order to economize on the alum, the pH value of the water is being reduced by the use of carbon dioxide gas applied at the mixing chamber of the secondary basin. A saving of more than two grains of alum per gallon seems to be promised and the water coming to the filters contains no mono-carbonate alkalinity that would encrust filters or piping beyond the plant. By means of the practice above related, it will be possible to produce excellent filtered water without the use of any chlorine; without increasing the cost of the water treatment over previous practice; and having as reserve processes, or factors of safety in the treatment, both the coagulation in the secondary basin and the rapid sand filtration.

Lime-Soda Softening Process for Small Municipalities. Experience in the industrial field has been copied and applied in convenient manner at two small municipal softening works in this state, where the fill-and-draw system of water softening is used. The settling basin also constitutes the mixing tank, the mixing being accomplished in one instance (Glendale) by mechanically operated agitators and in the second instance (Batavia) by compressed air. The charge of chemicals is applied while the tank is filling with water. Fundamental principles of water softening are taken advantage of, in that mass reaction of the chemicals with the water is obtained; efficient mixing by mechanically operated agitators takes place; and a perfectly quiescent settling condition prevails, because the tank is allowed to remain idle before water is drawn off to the filters from the surface by a floating outtake. It has been our experience that the fill-and-draw system of softening by the lime-soda process is

better adapted for the very small plant than the continuous flow system.

Municipal Zeolite Softeners. The employment of the zeolite process for municipal water softening is of fairly recent occurrence in this state. One plant is under construction for a small community, and two others are proposed for immediate installation. Advantages of this process over the lime-soda process are pronounced in the case of the small community which already has an adequate supply of well water of good sanitary quality. Some of these advantages are the following: By operation of convenient by-passes any degree of hardness desired may be permitted in the final product; the installations are compact; they are considerably cheaper to install; operation costs are about the same; and very little supervision is required.

Natural Recarbonation. Oberlin has the oldest municipal water softening installation in the country utilizing the lime-soda process. Incrustation and depositing of carbonate of lime have occurred extensively in the distributing system. The excelsior filters originally provided were abandoned last year when Oberlin began the practice of natural recarbonation, which was made possible by the use of an existing large open reservoir for the storage of the treated water. Chlorine is applied to the final product delivered to the system as a factor of safety on account of the open storage of the treated water. The results have indicated that enough carbon dioxide is absorbed from the atmosphere in the thirty days or more of storage to furnish a stability of softening reactions. Although all of the normal carbonates are not converted by this atmospheric absorption it appears that the depositing portion of these carbonates is eliminated. It is too soon to state if the open storage of such water will not invite other difficulties such as algal growth.

Iron Removal and Softening. Ohio has about 15 iron removal plants in which ground water is treated. The original devices used were aeration, sedimentation and rapid sand filtration. The fundamental principles involved in iron removal practice, as regards Ohio conditions, have been well stated by A. E. Kimberly in his paper published in the Second Annual Report of the Ohio Conference on Water Purification, as follows: (1) The water must be thoroughly oxidized to precipitate the iron. (2) Some of the precipitated iron is colloidal in character, but may be coagulated by catalytic action in contact with previously precipitated iron sludge. In the newer types of plants, therefore, sedimentation is being abandoned in favor of contact filters.

At one recently completed plant (Newton Falls) the devices are placed one above the other, on what might be called the "skyscraper" plan. The water from the wells is pumped to nozzle aerators located at the top of the structure, which spray directly upon the contact filters, from which the water flows to the sand filters at the first floor level; the effluent from the sand filters is collected in the clear well substructure.

At another plant it is proposed to substitute for the silica sand in the rapid sand filters zeolite sand, in order that the water may be softened in addition to the iron removal. The experience of the past year would seem to show that contact filters are very efficient in bringing the iron out of solution and in removing the greater portion of the iron. Therefore, the use of the zeolite in place of the filter sand should result in satisfactory softening without the zeolite being interfered with by iron depositing around the zeolite particles.

There is a general trend toward municipal water softening in all new development of water treatment in Ohio. It seems that our people are requesting a soft product as well as a pure product and this requirement appears to be independent of whether the water supply is of surface origin or of ground water origin.

Discussion of New Water Purification Devices

Coagulant Feed Devices. Up until a few years ago coagulant was applied at practically all plants by means of solution feed tanks and orifice devices. With one or two exceptions all of the last 10 or 12 plants constructed in this state have utilized dry feed apparatus for applying the chemicals. Reluctance in changing from the solution feed to the dry feed system was observed at first, due to mechanical difficulties encountered in the earliest types of machines; these difficulties have been largely eradicated.

For application of the coagulants it was common practice five or ten years ago to provide metal piping of special character, these pipes being imbedded in the concrete of the filter plant structure. Clogging troubles have demonstrated that it is advisable to place piping in ac-

cessible locations, and provide for short travel of the chemical from the machine to the point of application. At all of the recently constructed plants flexible hose of rubber or composition material has been employed, and experience indicates that clogging troubles are now practically nil. These hose pipes are placed in the open and the most direct route from the chemical machine to the water receiving the chemical is taken.

Mixing Devices. Early design employed gravity baffled mixing chambers, with either horizontal or vertical flow of the water and long periods of retention, many of the plants having as much as one hour in the mixing chamber. None of the new plants installed in the last two or three years in Ohio use this type of mixing. One style of gravity mix, however, is now employed, namely, the hydraulic jump. The new Baldwin filtration plant at Cleveland used this device, which was developed by J. W. Ellms, engineer in charge of water purification at Cleveland. This style of mixing chamber utilizes velocity head for a very efficient mingling of the chemicals with the water. With the exception of the Cleveland plant all other new plants in this state are utilizing some variety of a mechanical mixing chamber. The incentive for this style was largely the experimental work done in connection with the design of the Sacramento filtration plant and corroborated by laboratory experiments of C. P. Hoover and others in this state. Two general types are used, the vertical hanging blades or agitators and the horizontal suspended blades. Generally two tanks are provided to give flexibility, each with individually operated single shaft agitators. At first more than one agitator shaft was employed in a tank, but experience indicates that undesirable velocities are set up which break the floc formed.

The tendency to use the mechanical mix is accounted for by some of the advantages obtained, as follows: The system does not utilize extra head through the device; ease of construction makes it possible to inclose the entire mixing chambers within the chemical house; likewise chemical feed equipment may be placed immediately adjacent, with direct application of the chemicals through short lines; in most instances less than 2-horse-power is required for operating each agitator; a definite velocity may be obtained irrespective of the changes in flow of raw water through the plant, and the velocity may be adjusted at will by varying the speed of the motor-driven mechanism. Generally speaking, these tanks are designed to hold about 20 minutes retention and the speed of the agitator is set to give the water a velocity of about 1 ft. per second.

Clarifiers. Municipal water treatment practice has copied from industry another device, the clarifier, which has been developed largely by the Dorr Company. There are three in service in Ohio, all three of them in connection with water-softening installations. The character and volume of the precipitate resulting from the raw water treatment determines to a large extent the advisability of installing thickening devices of this nature. For the most part turbidities are not encountered in Ohio that would warrant the installation of clarifiers in ordinary water treatment practice. The three softening plants employing Dorr clarifiers are Newark, Greenville and Piqua. The first installation was circular in style, but the two recent ones are square. The water is retained about one hour and permitted to flow through the clarifier at a low velocity of travel, somewhat less than ½ ft. per minute. The mechanically operated thickener is set for a slow rate of travel, usually about 4 revolutions per hour.

The advantages of the clarifier, particularly for water softening practice, are seen from the results cited for the Newark plant. The clarifier removes about 98 per cent of the total suspended matter present in the water leaving the mixing chambers. Another advantage is that sludge removal may be conducted continuously and in less objectionable manner. This item is of particular importance where a small stream must receive the discharge of the sludge and waste water from the purification works. A striking inference may be drawn from the performance of the clarifier in the softening practice, namely, the great reduction in size of settling basins needed prior to filtration.

At the Newark plant installed two years ago regular practice was followed and settling basins holding 8 hours of supply were constructed. Based upon the performance of this plant, the Greenville and Piqua designs have reduced the settling basins capacity to retentions of from 2 to 3 hours. In the latter design a by-pass of the settling basins has been arranged in order to determine whether or not all of the settling basin may be omitted.

Carbon Dioxide Application Equip-

ment. Carbon dioxide gas is employed in water treatment at several plants in this state; for the most part this treatment is used at softening plants for the prevention of after-precipitation of mono-carbonates. There are two general features of carbon dioxide application, the generation equipment and the absorption chambers.

Research work is still going on with regard to the best method of generating carbon dioxide for water treatment practice. In Ohio four plants are using coke for fuel, one uses oil, one uses powdered coal, and one contemplated will use producer gas. Based upon the experiences thus far it would seem that burning of coke affords the best way of obtaining carbon dioxide for the medium size and small plants. For very large installations it appears now that the burning of producer gas will be the best. It is this type of installation that the city of Columbus is going forward with. The producer gas will be manufactured first by burning coke with a restricted air supply for draft and the resultant gas then burned under the boilers, in order to utilize the heat of burning of the producer gas. The chimney gases from this boiler will then carry a very high percentage of carbon dioxide and be quite serviceable for carbonating the large volumes of water at this plant. It seems desirable to include with the generating equipment a scrubber and drier to take out impurities from the gas that might affect the compressor. Experience at two plants has shown that the compressor is affected if insufficient scrubbing of the gas is done before compressing. However, one new plant (Girard) is employing a new type of compressor that is water lubricated, which promises to make possible the omission of scrubber and drier as a preliminary to compressing the gas.

At the first plant to install carbon dioxide equipment (Defiance) special provisions were made to cause the gas to be absorbed by the water. A carbonation chamber was arranged that had filtros diffusers to break up the gas in small bubbles; also baffled compartments to cause the water to travel downward against the upward flow of bubbles, and drainage facilities to take away possible precipitates that might be formed. Experience has shown that the precautions cited are not needed to obtain satisfactory carbonation. The recent plants are employing the last portion of the settling basin, say a capacity of 30 minutes retention, instead of providing separate basins. No particular baffling is done except to partition off this compartment from the remainder of the basin and thus prevent the disturbing of suspended matter already settled out in the basins. For distributing the gas ordinary grids of piping with small perforations, say from 1/16 to ⅛ in., are giving good satisfaction. Tests with such piping show that over 90 per cent of the carbon dioxide applied is absorbed even when the depth of the water is not greater than 8 or 10 ft.

Conclusion

In conclusion, the writer wishes to state that the material presented in this paper is drawn largely from the work of the Ohio Conference on Water Purification, and credit for new thoughts gleaned belong to the men in charge of the particular plants cited. This Conference comprises the men actively in charge of the water treatment plants. They have met with the State Department of Health annually for the past five years, and the Conference has thus become the medium of exchange of ideas, experiences and the results of research studies.

GENERAL HIGHWAY ADMINISTRATION AND PROGRESS

By Wm. M. Jardine, Secretary of Agriculture, Washington, D. C.

(Paper read at 1926 meeting of American Association of State Highway Officials.)

The decade just past has been marked by greater improvement of the roads of the United States and a larger increase in highway transportation than any other in the history of the country. As from our present position, we look back upon the way we have come in these ten years the progress seems truly remarkable. Coincidentally this same period covers the span of the Federal aid road legislation and its administration under the Department of Agriculture.

As we entered the decade in 1916 there were less than two and a half million motor vehicles in the entire country, and less than 73,000 of these were registered as motor trucks. Today the trucks alone are more numerous than all motor vehicles at that time, and the total has doubled and twice redoubled in the ten-year period.

In 1916 there were approximately 277,000 miles of surfaced roads in the entire

country, only a small percentage of which were of the types now regarded as adequate for motor vehicle traffic. Today the mileage of surfaced roads is nearly if not quite twice as great as it was 10 years ago and more than 100,000 miles are improved with types of surface more satisfactory for service than waterbound macadam—a record of progress the more remarkable if it is remembered that during this same ten-year period it has been necessary to reconstruct a very large part of the mileage previously constructed.

Ten years ago there were only five States in which there was as much as a single improved transstate highway. They were Massachusetts, Connecticut, New York, New Jersey, and Maryland—all Eastern States and all of that small group in which the movement for better highways had been begun in the nineties. Today 25 states have improved highways continuous from border to border in at least one direction and 16 of these have completed such transstate arteries in two directions.

In 1916 there were 16 states in which there was no State highway department that could be recognized as competent to administer the construction of Federal-aid roads, and they had no semblance of a plan for the development of a State system of highways. Even in those States in which the recently created State agency was endeavoring to introduce scientific and businesslike methods of highway improvement there were only a few in which a connected State highway system had yet been clearly conceived. Today there is in every State a definitely designated State highway system to the improvement of which the state governments are applying their resources.

These remarkable changes occurring within the brief period of 10 years, distinguish the last decade as the most important in highway history; but the developments which are destined to have the most far-reaching influence upon the future are the establishment of the Federal-aid policy and the elaborate and productive researches which have been carried out by the Federal and State departments and other agencies.

Of the Federal-aid policy it may be said that the 56,000 miles of road which have been improved under it are of less signifiance than the principles upon which the policy is founded, and which are thus given nation-wide importance.

It is a first principle of the Federal-aid policy that all roads, by the nature of their traffic, are stamped as of local, State or interstate importance, and that this fact should be recognized in the administration and financing of their improvement. The law has, therefore, required the designation of a definite Federal-aid highway system, including those roads of interstate importance in the improvement of which the national and State governments may properly combine their efforts.

From the first it has been required that the State should, itself, participate directly with the Federal agency through a department of its government competent to assume the responsibility. In retrospect, this provision of the law appears as, perhaps, the most important Federal contribution, responsible, as it doubtless was for the creation and strengthening of highway departments in many of the States. It is a notable fact that these organizations are among the most efficient of State institutions, and it is certain that to them must be ascribed the largest measure of credit for the remarkable improvement of our highways. There is gratification, also, in the splendid cooperation which has at all times marked their relations with the Bureau of Public Roads.

The importance of the contributions to engineering science which have resulted from the research and experimentation that has been so vigorously conducted since 1920 can scarcely be over-emphasized. The Bates Road tests by the Illinois department, the Pittsburgh, California, experiments and the various tests of the Bureau of Public Roads are known and studied throughout the world. By the general adoption of the thickened-edge section, a direct result of this research, the public has already benefited through increased service and lower costs, and the saving will go on as long as concrete roads are built.

As the result of a single study completed recently by the Bureau of Public Roads by which it has been demonstrated that brick of two and two and one-half inches in thickness may be used to give the service for which three and four inch brick have previously been used, it is estimated that large annual savings are possible. A few thousand dollars and the earnest and devoted work of three or four of the bureau's engineers for less than a year have thus returned to the taxpayers of the States and municipalities, wherever brick pavements are built,

many times the expenditure in potential cost reduction.

Similarly the bureau's studies of grading and concrete pavement operations have pointed the way to an improvement in the efficiency of such operations as a result of which it has been found possible in some cases with the same equipment to increase production by 50 to 100 per cent.

The results of these studies are immediately apparent in reduced costs and enhanced efficiency. In other cases, as in the studies of soils to determine their characteristics as highway subgrades and in the various investigations of the effect upon roadways of traffic and climatic influences, the object sought is complicated by so many variable factors that the studies must be long continued before definite results may be expected. But these researches, penetrating as they do to the very fundamentals of highway design, are likely in the end to be the most valuable of all, and it is not only possible but probable that future generations of road builders may regard them as in the same category as those fundamental observations by which the design of bridges has been converted from a rule—of thumb process into an exact and dependable science.

Turning from retrospection to the contemplation of the future, I am impressed with the necessity of making adequate provision for the increasing service that will be expected of the highways. If the number of motor vehicles has increased from two and a half to twenty million in ten years, there is no reason to believe that the increase will be abruptly halted now, although we may expect some falling off in the rate. As traffic increases directly in proportion to the motor vehicles in service we must expect that the conditions for which we now build will be intensified in the future. The highway service we are now providing must be capable of expansion to meet the needs of the growing traffic as these mature.

Doubtless the concern of the immediate future is not for all of you the same. To some it is the completion of an initial improvement of a large mileage, previously unimproved, in the face of a demand for more adequate facilities on some of the highways already well developed. To those who face this situation the problem is to get the traffic through —to effect some degree of improvement over a whole highway system as rapidly as possible in order to give the greatest satisfaction to the greatest number of people.

Others among you—more fortunate, I believe—have systems of main roads already improved and largely surfaced, and the immediate concern is the selective betterment of sections of the system to relieve congestion, eliminate danger, and generally to adjust the existing improvement to the growing needs of a still increasing traffic.

To all alike, however, the problem of the present is to serve as adequately as possible the present needs, keeping in mind at the same time the greater needs of the future, and making suitable provision for their accommodation when the time arrives. This is the policy of stage construction, a sound policy because it recognizes the utter impossibility of building once for all a system of highways which may be regarded as a finished product, but rather substitutes for that conception, the principle of progressive improvement.

The construction of earth roads on the lines and grades and with the drainage provisions that will be required by the pavement of the future is a recognized application of the stage-construction principle. But it has much wider applications than that. The acquisition of rights of way of ample width for the future so that, when the need arises, it will be possible without heavy expense or the injury of private property to effect the necessary improvements, is another highly important application. The same foresighted policy suggests the location of the improved highways in relation to railroads at crossings in such manner as to provide satisfactorily for separation of grades, and it applies also to provisions for the construction of future by-pass highways around cities, and for the diversion of traffic from routes of growing congestion.

To anticipate thus the needs of the future implies a knowledge of the probable traffic importance of the various roads which can only be obtained by a careful and detailed study of the present distribution and the factors inherent in the economic and physical characteristics of the State. Such studies have been made by the Bureau of Public Roads in co-operation with the highway departments of a number of the States, and the reports, recently published, are doubtless familiar, to many of you.

The highway department that has in its possession such information as these surveys supply can really plan for the

future. It has substituted facts for opinions; it knows the present and probable future importance of its roads; it knows the density and also the weight of traffic to which each road is now subjected and to which it is likely to be subjected in the near future. It can, therefore, devise a reasonable program of construction extending into the future; it can budget its funds intelligently; it can determine the order in which the various highways should be improved and give a satisfactory answer to those who favor priority for other roads; and it has in its possession an adequate basis for the necessary decision as to the character of improvement required for each road.

This is sound and businesslike administration of highway improvements. It is the reverse of the casual and haphazard procedure which too often has subjected the business of highway improvements to political manipulation, and produced discontinuous, unbalanced, and uneconomical development instead of well articulated systems of improved highways.

In the Federal-aid work we feel the need of such precise information daily and I look forward hopefully to a not far distant time when it will be available in all states.

Not all the exact information it is possible to obtain, however, will suffice to provide an orderly and systematic improvement of the main roads in the States which will rely upon the financial assistance of the counties to carry out the State program. Certainly there has been experience enough to prove that complete connection of main arteries is practically impossible so long as there is dependence upon county financing. The reasons are perfectly obvious. All sections of the major State roads in the various counties are not invariably the roads in which the county interest is the greatest. By their very nature the roads of the State and Federal-aid systems are the most heavily travelled highways. In many instances the traffic which demands their improvement is contributed in a smaller degree by counties through which they pass than by other counties or even other States. It is not unnatural that the authorities of such counties should be unwilling, and they often are financially unable, to assume a share in the cost of the improvement. So long as any State fails to provide State funds for such roads the development of the main State and interstate roads along strictly economic lines will be hampered.

Full operation of the provision of the Federal highway act which aims to correct this condition has been twice deferred in the Federal legislation to give States concerned more time to correct their laws. There ought to be no further delay. I am sure that the members of this organization from the affected States will join with me in the hope that the necessary laws and constitutional amendments will be provided before the Congress shall again have this legislation before it for further action.

It is manifestly unfair to the counties themselves to expect them to participate in the cost of improving the main lines of traffic. To do so places a burden upon them which they should not be expected to bear. The improvement and upkeep of the roads tributary to the main systems are of the highest importance to agriculture and the county and local funds must be preserved for this purpose. The traffic on the State roads is a wide-ranging traffic. The greater part of it originates in and is destined to the cities, and any system which causes the rural communities to contribute to the expense of improvement in greater proportion than the benefits they derive is unfair and ought to be remedied.

Looking to the future also there must be a still greater improvement in the maintenance of all roads and especially of the Federal-aid roads, and obligation which the Federal law places upon the State highway departments. While unquestionably there has been great improvement in this respect during the last decade, the failure to make proper provision for the repair of roads upon which large sums of public money have been invested is the sheerest of economic folly. Unless there is positive assurance that means will be available for the constant and continuous care of the roads after they are improved, I am convinced that it would be better not to improve them at all.

It has not often been necessary to enforce the provisions of the Federal highway act in respect to non-performance of the necessary maintenance work on Federal-aid projects. With few exceptions the obligation of the States has been carried out. There are a few—no more than can be counted upon the fingers of one hand—upon whom it has been necessary to call repeatedly for essential work to save the Federal-aid roads from deterioration. The department has been patient in dealing with such cases and our requests have always been met with

a response, but maintenance that is delayed until the deterioration has advanced to the point where it becomes necessary to direct attention to it, is not the right kind.

While the States in accepting the Federal appropriations accepted also the obligation of keeping the roads in proper repair, the deeper obligation is that of rendering the best possible service to the public and of protecting public investment. Neither the public nor the legal obligation can be satisfied by a perfunctory highway maintenance policy. The department has endeavored to deal in a straightforward way with its duty to enforce the law in this respect. There has been no tendency to pick flaws of a minor character or to look with unsympathetic eyes upon the effects of the States. It is not a pleasant duty to serve a formal notice required under the law upon any State, and it is still less pleasant to withdraw Federal participation. The department believes, however, that its first duty is to insure proper maintenance of the roads constructed with Federal funds, and this viewpoint I am sure will have the unanimous support of this Association. There are a few States in which there have been too frequently reports of projects in an unsatisfactory state of maintenance, and may I take this opportunity to urge very seriously upon these States, which cannot themselves be satisfied with such conditions, their immediate correction. The department wishes to make clear its position that the duty to maintain roads already constructed is paramount.

With each year's progress now it becomes easier to see the working out of one of the primary conceptions of the Federal-aid road legislation as expressed in the requirement to expedite the completion of an adequate system of highways interstate in character. It was foreseen that the fulfillment of this purpose would come through a linking up of sections of main highways as they are developed State by State, and up to this time the programs within the States have in general been in harmony with the expected progress in the direction of through routes. In some cases the department has taken definite positions with reference to specific projects to provide missing links, usually in the way of bridges at State boundaries, but now, with the major routes of the country so clearly defined by the action of the States through this Association, the unimproved sections of these routes have been brought in strong relief. It is now possible to travel from Washington through St. Louis, Texarkana and El Paso to San Diego, over a transcontinental route of which 97 per cent is improved, 93 per cent is surfaced and 4 per cent is graded and drained. Of the surfaced portion more than half is improved with bituminous macadam or higher cost types and the remainder is gravel. From Washington to St. Louis there is no unimproved section and nearly 96 per cent is surfaced with bituminous macadam or one of the higher type roadways. From St. Louis to Texarkana, 2 per cent of the distance is unimproved and 63 per cent is improved with a gravel surface, the rest with superior types. From Texarkana to El Paso there are unimproved sections equaling 4 per cent of the distance, gravel surfaces 50 per cent and bituminous macadam or superior type the rest of the way. From El Paso to San Diego, with the exception of 6 per cent of the distance, the road is surfaced, 60 per cent with gravel and the remainder with pavements and surfaces of higher types.

This is the possible transcontinental route, totaling 3,133 miles, most nearly surfaced; 2,907 miles are surfaced and 131 miles are graded and drained, leaving only 95 miles without improvement. This route does not coincide with any one of the United States routes but it does indicate the splendid progress that has been made by the States it traverses in the completion of important transstate routes. Considered from the standpoint of improvement, the next ranking transcontinental route is that from Atlantic City to Astoria. Of its total length of 3,240 miles, 12 per cent is still unimproved, another 12 per cent is graded and drained, and the remaining 75 per cent is improved with some form of wearing surface. Of other east and west routes, that from Norfolk to Los Angeles is 68 per cent improved and that from Chicago to Los Angeles partly by the same line is 63 per cent improved. From Boston to Seattle, through the northern tier of States, the most direct through route is 73 per cent improved and 69 per cent surfaced.

These routes are taken to illustrate the working out of the principle, as defined in the Federal highway legislation, of the completion of interstate routes. There may be critics who hold that the ten-year period covered by this legislation should have produced more transcontinental routes fully improved. There are two

answers: The actual operations of the Federal highways legislation did not get under way until well into the year 1919, and the tremendous development of motor vehicle traffic, particularly around every center of population, large and small, local rather than transstate in character, has necessitated first attention to the immediate service demanded. It is my feeling that the progress in the completion of transcontinental roads is gratifying, but I do not lose sight of the fact that the lack of transstate routes in the agricultural States of the Mississippie Valley is not in keeping with the development, east and west. In specific States this condition is brought about more largely by the feature referred to above, that is, the dependence upon county financing, than upon any lack of need of such roads or lack of response on the part of the State highway departments. Now that there has been plainly pointed out and defined the through routes which are of major national importance, there should be an energetic effort made to improve the missing links, not because they are transcontinental routes but rather because in general these unimproved sections lie on the most important State routes, and the failure to improve these imposes a handicap upon the people of each State in the satisfactory use of their own road systems. But the national use must not be lost sight of, nor the requirement of the national legislation that these interstate routes shall be expedited. The department has not attempted to dictate the routes which should be regarded as major State routes. Neither for that matter have the State highway departments. Through the careful work of the Joint Board on Interstate Highways, and the Executive Committee of the Association, each State highway department has expressed in a definite way the routes which are of the greatest importance within the State. In other words, this system of interstate routes has been built from the local viewpoint upward and not from the transcontinental viewpoint downward.

But having now settled upon these routes, which in the last analysis the public itself has defined by their use, it becomes our duty, the Federal and State highway departments working in co-operation, to expedite their completion. There are approximately 80,000 miles of highway included in these routes. To complete them to a state of improvement satisfactory for present use is a matter of closing gaps. I am convinced that this, the initial improvement, can be completed by 1930 without difficulty, and as a definite objective I can think of no expenditure of effort which would bring with it a greater return of public satisfaction or any more intelligent method of keeping faith with both the Federal and State Governments which have entrusted to us the administration of these large funds.

The uniform signing and numbering of the United States highway routes in accordance with the reasonable plans now devised are essential in order to establish it in the public mind as an entity. They are needed also to develop the maximum degree of service and safety in their use by the ever increasing public traffic. From the Federal point of view the early improvement of these routes is of large importance, and I ask your full support in an effort, when these designated routes shall have been ratified by this association, to complete the unimproved links at the earliest possible time and to bear with this department in a reasonable but insistent demand that the Federal funds so far as possible be dedicated to this purpose with the full consent and belief on the part of the highway departments that the end is desirable and worthy. I esteem it a privilege and it has been a pleasure to meet with this association, to know in more detail of its work, and to have the opportunity to express to you my high appreciation of the character of men who are engaged in this public service, and my sincere thanks that the unfailing co-operation of the highway departments has lightened the duties of my administration as Secretary of Agriculture.

THE TOWN ROAD PROBLEM

By N. J. Isabella, Maintenance Engineer, Wisconsin Highway Commission, Madison, Wis.

(From "Badger Highways" for July, 1926.)

The local, or town road, while it is not used to the extent of the primary or secondary roads, is a very necessary link in our highway transportation system. Statistics show that 82 per cent of all raw materials are produced on farms; 14 per cent from the mines; 3 per cent from the forests; and 1 per cent from water. Using these figures, it is very evident that the hauling of produce from the farms to market is a proposition of considerable magnitude. The load which a farmer can bring to market is regulated to a

very large extent by the local road or the feeder to the main highway. The grades, surface, and structures are determining factors in the size of load that can be transported to market.

During the last fifteen years the efforts of the counties and states have been directed mainly to the improvement of the primary and secondary highway; in other words, the state and county trunk systems. In Wisconsin we have approximately 78,000 miles of rural highway; 10,000 miles of this is on the state trunk highway system and approximately 11,000 miles comprises the county trunk highway system. The balance, or 57,000 miles, constitutes the town or local roads.

Considerable money is being spent each year by the local units of government in trying to improve town roads, but as yet comparatively little has been accomplished toward the development of a connected inter-town road system. The greater part of the 57,000 miles of town roads is plain earth road, some of which has been graded to a fair cross section, but a large mileage of it is practically untouched, as far as grades, alignment, and structures are concerned. Probably one fault that has existed in the past in the improvement of town or local roads is the lack of centralized authority to carry out the economical performance of the work. Authority has been divided, and as a result the efforts have not been united.

It is my belief that not until there is centralized authority in the building of town roads will we have satisfactory results. If one looks back a few years he can see the development that has taken place on the through highways and that the connecting up of centers of population and farm to market has been made possible only through centralized authority in highway building.

The problem as I see it now is not one of spending larger sums than are being spent at present to improve the local roads, but is one of getting the most out of the expenditures made. Many of the towns and local units have seen the advantages of a well maintained surface and realize that the cost of hauling produce over such a surface is much less than the cost of hauling over a poor and uncared-for highway. Quite a number of the towns have taken advantage of the experience gained by the counties and the state and have adopted small patrol systems on their town roads. This is really the first step toward getting an adequate transportation system in the town.

The ordinary patrol work will suffice under ordinary weather conditions, but in the sections of the state where heavy clay soils predominate there is very little that can be done during and immediately after rains. The problem is, therefore, one of placing a surfacing on the clay road so that it will be possible to use motor-driven vehicles at any season. In the case of the sand road the surface may be improved with clay or top soil if gravel, shale, or stone is not available. By this it is not meant that all local roads should be graded to a standard cross section and provided with high class drainage structures and surfacing, but, on the contrary, to provide a surface over which the farmer's vehicle may pass during any season. In the majority of cases the drainage structures on the present town roads, while they are not of ample width, they will, with very little expenditure, take care of the drainage and suffice for local road purposes. Those structures which are weakened by age and will not permit the heavier loads should be repaired or reconstructed first.

The farmer in many Wisconsin communities is more or less isolated during certain periods of the year due to the poor condition of the local roads. The local road is the barrier between the farm and market, and it would seem that if the towns are to better their present condition the work must be well planned in advance. A definite program should be outlined at least five years in advance and then should be adhered to. We must get away from the idea of placing all the town funds in one small section of road by building it to a standard of a highway that carries one hundred times the traffic of a local road.

The funds should be spent over a longer distance, and the more urgent demands should be taken care of first. The time is coming when the towns will want the county highway authorities to go into their locality and build the roads for them, using the county equipment forces. In this way the work can be done with greater economy. It will obviate the necessity of towns purchasing equipment and they will also have the advantage of the experience gained by the county forces in the building of highway.

If the money to be expended by the towns on town roads were available for the construction and maintenance of town roads by the county forces, it would go a long way toward connecting up im-

passable gaps on the present town road systems. This statement is not made in the way of criticism, but to point out that in many cases work can be done by the county forces at a great saving to the town.

I do not believe that anyone will question the fact that given a certain sum of money, more miles of road can be constructed by an organization that is primarily doing road work than by an organization that is temporarily assembled to do the work. When you consider that there are 1,270 towns in the state and that if each town were to purchase and equip itself with proper and sufficient machinery to handle all road improvement you would find this would take large sums of money. Consider also the organization necessary and the lost motion that may and often does occur where the work is only temporary; also, the loss in depreciation of machinery which is not properly cared for.

Much of the equipment used by the towns is left along the roadside and allowed to deteriorate due to lack of a central shop or storage place such as all counties have at the present time. It is true that if the counties were to handle all town road work they would require additional storage and repair shops and more equipment, and they would have to employ more men. However, the additional expense would be more than offset by the results obtained under centralized control.

Under the new state highway law, every mile of town road which is not on the county or state highway systems is entitled to receive $25 per year. In some towns this does not mean a very large sum, but in others it runs up to two or three thousand dollars. In many cases the towns are requesting that the expenditure of these funds be made by the county highway forces. This is a wise plan and it is believed that more towns should avail themselves of this privilege. The result will be more miles of roads for the expenditure made.

I have in mind the town of Glen Haven, Grant County, which established a definite program a few years ago to surface the most important roads in the town, thus connecting the farms with the villages and railroads, and making it possible for uninterrupted traffic during all seasons. This town set out with a definite idea and has practically completed the plan as outlined several years ago. There are several others that have done this, and if you were to ask any resident in these towns if they would sell their road systems for what they paid for them, plus a good interest charge on the investment, and go back to the old system of impassable highways, they would be unanimous in voting to retain their improved highways. The roads built have more than paid for themselves, and the business men, farmers, bankers, and all others concerned are in better financial condition today than they were before the roads were built. The building and maintaining of good roads is a plain business venture, which, if properly executed, will net good returns on the money invested.

Considerable progress has been made on the state and county highways. Much more remains to be done to take adequate care of the ever increasing traffic. The gradual improvement of these systems is practically assured by the present highway laws, and public sentiment that demands a continuance of construction and maintenance. More attention must now be directed to the solution of the local or town road problem to eliminate the barrier between farm and market.

The road of fifty years ago does not meet the requirements of present day transportation; likewise, the methods in road building employed years ago cannot be economically used today. We must therefore make a change for the better and put local road building on a higher plane, through co-operation between town, county, and state. Experience gained by the county and state may be successfully put into practice by the towns, and where this is done real highway service will be rendered, not only to the user of the primary highway, but to every farm on the public highway.

BINDER MATERIALS FOR GRAVEL AND STONE ROADS

By C. L. McKesson, Materials and Research Engineer, California State Highway Department, Sacramento, Calif.

(From "California Highways" for October, 1926).

The testing and research laboratory has been endeavoring for a considerable period to develop tests which will determine the relative efficiency and suitability of binder materials. The following description, which may be considered a progress report covering present practice, it is hoped, will be of particular value to field engineers in interpreting test reports issued from the laboratory.

Proper selection of binders or fillers for the considerable mileage of gravel and crushed rock surfacing heretofore constructed, in locations where proper fillers or binders were difficult to obtain, has been the subject of considerable investigation.

On new construction rock and gravel intended for surfacing is sometimes found to be lacking in cementing properties, but otherwise to be suitable for use. To remedy the deficiency in binding or cementing properties, it has become the practice to add binding material by mixing it with the surfacing during construction or later by blading and mixing on the road.

Suitable binder material usually consists of distintegrated or weathered rock or clay and sand mixtures. The term "clay binder" is quite commonly applied to such material, but is not always an accurate description. So-called "sticky clay binders" have been tested which contained less than 25 per cent of clay and more than 75 per cent of sand and silt and which, therefore, fall entirely outside the class of soils known as "clays."

Fine Material Essential

In general in making cementing tests of surfacing materials, it has been found that the road metal must contain at least 15 per cent of material passing a 100 mesh and 8 to 10 per cent of dust (removed in the washing test). These percentages are in terms of the portion of surfacing passing one-half inch circular opening screen. Except with very soft rock which grinds up rapidly under traffic, a less percentage of fines will usually result in a loose dusty surfacing. Some road metal does not show satisfactory cementing value even with larger percentages of fines, due to the inert nature of the material, but even with high cementing properties in the material fines are essential in about the minimum quantities stated.

Cementing tests on surfacing metals are made on the portions passing one-half inch screen with a minimum dust content as indicated above.

How Tests Are Made

The sample is moistened and mixed as in the preparation of a concrete sample. The amount of water used varies with the character of the material, but an effort is made to approach the condition known in soil tests as moisture equivalent saturation. The same consistency in concrete would be defined as "stiff." With ordinary crushed rock surfacing material, the amount of water usually runs from 10 to 12 per cent. The material, after wetting, is tamped into a 4½-in. cubical mould and is placed in a warm oven at a temperature of about 100° F. until it has dried sufficiently to permit its removal from the mould. Drying is then continued until the specimen ceases to give off moisture, after which it is capped with plaster of paris and tested for compression in a Universal testing machine.

The cementing value is taken as the average compressive strength per sq. in. of three specimens. There is a wide variation in results obtained with different materials, but fairly uniform results can be obtained in repeated tests of the same material. The strength developed ranges from zero to about 225 pounds per sq. in. One hundred to 150-pound strengths are not unusual.

Binder materials are tested in a similar manner except that clean concrete sand all passing a one-half-inch screen is used as a basis, the binder material being added in an amount sufficient to bring the fines up to 15 per cent passing 100 mesh and about 10 per cent of wash. The clean concrete sand has no cementing value and the strength of specimens containing the mixture of binder and sand is, therefore, due to the presence of the binder and represents the cementing value of the binder material.

In addition to cementation tests, binder materials are tested as soils for moisture carrying characteristics and for lineal shrinkage.

Practice in Binder Tests

A recent study of the suitability of a so-called "clay" binder will serve as an example with which to illustrate our practice in binder tests.

The "clay" binder tested as a soil was found to contain 21 per cent of clay, 26 per cent of silt, and 53 percent of sand. The moisture equivalent was found to be only 13 per cent, indicating it to be a soil which will not retain an excessive moisture content in wet weather. Lineal shinkage was found to be only 3 per cent, showing it to be a stable soil not greatly affected in volume by alternate wetting and drying.

In the cementing test, with clean concrete sand, using 26 per cent of binder and 74 per cent sand, a compressive strength of 128 pounds was obtained. This was considered a satisfactory cementing value.

This binder material was used to cement a crushed gravel surfacing of

granitic material which, with its own stone dust, had only 50 to 60 pounds of cementing value. This low cementing value rendered the material unsuitable for use.

This surfacing material was mixed with the binder described above in the proportion of 85 per cent of surfacing rock, including stone dust and 15 per cent of the binder. The cementing value on the mixture was 155 pounds per sq. in. and indicated that the addition of 15 per cent of binder was sufficient to insure satisfactory results. Subsequent tests on field samples of binder and crushed material as mixed and delivered to the work showed cementing values of 125 to 150 pounds.

Motor vehicle traffic has made the quest for a suitable and efficient binder for rock-surfaced highways one of the important tasks confronting highway engineers. Whatever the laboratory can contribute to that end it will gladly do.

ANNUAL MEETING OF PORTLAND CEMENT ASSOCIATION

G. S. Brown, president of the Alpha Portland Cement Company of Easton, Penn., was elected president of the Portland Cement Association at the annual meeting conducted at the Drake hotel, Chicago, November 15, 16 and 17. Mr. Brown succeeds Blaine S. Smith, vice president and general sales manager of the Universal Portland Cement Company.

Col. E. M. Young, president of the Lehigh Portland Cement Company, Allentown, Penn., and Robert B. Henderson, president of the Pacific Portland Cement Company, San Francisco, were elected vice presidents. John W. Boardman, vice president of the Huron Portland Cement Company, Detroit, was re-elected treasurer.

New members of the board of directors are: L. R. Burch of New York City, vice president of the Atlas Portland Cement company; Richard Hardy of Chattanooga, chairman of the board of directors of the Pennsylvania-Dixie Portland Cement Corporation; Blaine S. Smith of Chicago, vice president of the Universal Portland Cement Company; L. T. Sunderland of Kansas City, Mo., president of the Ash Grove Lime and Portland Cement Company; and C. E. Ulrickson of Dallas, vice president of the Trinity Portland Cement Company.

During the three days of the convention many problems were discussed in committee meetings and in general sessions. A "Symposium on Dust Collection" was presented Tuesday, November 16, by J. B. Taylor who spoke on "Some Aspects of the Dust Problem;" J. H. Kempster whose topic was "Dust Collection and Prevention in Packing and Grinding Departments;" Walter A. Schmidt who talked on "Electrical Precipitation of Dust in Portland Cement Plants;" and Frank Moyle who spoke on "Cyclone Dust Collectors."

Progress in accident prevention work was reported by the accident prevention committee. During October 73 of the 127 plants reporting came through without a single accident. Each year a substantial reduction in accidents has been secured over the previous year and now mishaps have been reduced by one-half since the formation of the Accident Prevention Bureau of the Association.

At the business session Mr. Smith, the retiring president, reviewed portland cement industry for the past year and pointed out certain conditions which will influence the industry in the near future.

Mr. Smith in part spoke as follows:

"Everything considered, it is not difficult to believe that unless something unforseen occurs a large construction program can be expected next year and consequently a good cement demand, although an increase over this year's consumption is not likely.

"A year ago if we could have been assured that shipments in 1926 would exceed those of the year before, most of us would have felt relieved. At that time prospects of such a showing were not promising, yet government figures for ten months indicate total shipments for the year of 162,000,000 barrels, or about three per cent more than the pervious year.

"Stocks on hand November 1 were the highest for that date in history and one-fifth greater than a year ago. Substantial curtailment during the winter is inevitable.

"Capacity to manufacture continues to increase. At present it is about 200 million barrels per year. The additional capacity of ten new plants and enlargement of old plants practically assure a total capacity of 215 million barrels next year. This is 33 per cent greater than this year's indicated consumption.

"In the last few years greatly increased storage facilities for both cement and clinker have been built, which in effect increase capacity. As the necessity of winter shutdown due to full stock

houses is reduced, this large excess of capacity over demand presents a serious problem.

"Complicating it is the menacing increase of cement imports. Within five years importations have grown from practically nothing to an estimated 4 million barrels this year. Those who are in direct competition with this imported product need no reminder of it, but perhaps some in the interior of the country do not fully realize its size and importance. Nearly one-half of the cement consumption of the metropolitan district of Boston in the first nine months of this year has been of foreign cement.

"As late as May, 1922, when the proposed duty on cement was under debate in Congress, it was stated many times that no foreign cement except that from Canada could enter into competition with American product; yet imports have jumped from about 325 thousand barrels that year to about 4 million barrels this year, with the peak not yet in sight. With Europe's labor getting about one-fifth of the day's wage of American workers, with low transportation costs and light overhead charges, Europe is dumping here these large quantities of cement at prices which American producers cannot profitably meet.

"Immediate tariff legislation is unlikely but pending the time when Congressional relief can be effected, government officials and national legislators should be made acquainted with the facts in the hope that they will not permit the error of opinion of 1922 to prevail. We should show public officials what the menace of this foreign enterprise is and where American dollars are being expended for the construction of public buildings and roads, we can rightfully insist that specifications call for an American product. American taxes should be spent for American goods and foreign cement should be excluded.

"The American cement manufacturer is not the only one injured. A pamphlet recently published by one of our large cement manufacturers shows that American industry lost $29,000,000 through the importation of 10 million barrels of foreign cement in the last five years. This loss is borne not alone by the capital and labor in cement plants but by American coal and oil industries, power companies, railroads, sack manufacturers, explosive and gypsum producers, machinery manufacturers and others. These facts should be made known to those who are fostering the use of foreign cement. We should influence buyers of the imported product to cease their patronage of foreign producers, not alone for patriotic consideration but for sound business reasons as well."

In speaking of the work of the Portland Cement Association Mr. Smith stated:

"We have found out in our laboratories many things new to the engineering profession which have been distinctly helpful in improving the methods of using cement. Tests have been devised which are now applied quite generally in construction work of note which enables engineers to determine in advance the quality of concrete which they are to use.

"Another line of development of technical knowledge which is very much worth while is the study of the constitution of cement clinker. The policy on which this work is being pursued is characteristic of the studies which have been made of concrete, namely, to establish basic facts about cement and not to try to support any previously established opinions."

The convention was closed Wednesday evening with a banquet at the Drake hotel with Blaine S. Smith acting as master of ceremonies. George Woodruff, vice-chairman of the National Bank of the Republic, spoke on "The Possibilities for 1927." Col. Sidney D. Waldon, president of the Detroit Rapid Transit Commission, also delivered an interesting talk on "Untying the Traffic Knot."

Mr. Woodruff in speaking of foreign competition with American manufacturers declared:

"We should not fail to realize that European competition is slowly gaining and that while it can hardly hit us as hard in 1927, it will doubtless be the factor that will ultimately bring about our next great period of business readjustment. If America were still a debtor country, we might be able to maintain our prosperity on a basis of very high production costs for a long time to come, but the fact that we are now the greatest creditor nation in the world makes the cost of production in our country a serious matter. The world must henceforth pay large sums of money to America every year and this can be done in but three ways—by sending gold, by sending goods or by sending stocks and bonds. We do not want more gold and foreign countries do not possess sufficient gold to send. Stocks and bonds will doubtless come in large amounts but this cannot

go on forever. Goods must then come our way and the force of competition will be felt by us in foreign trade and here at home. Only through the tariff can we guide from our ports the goods that will do the greatest harm and let in the things that will hit domestic output least."

DEVELOPMENT OF WATER SUPPLY AT TONGANOXIE, KANSAS

By C. A. Shockley, Mem. Am. Soc. C. E., Consulting Engineer, Graphic Arts Bldg., Kansas City, Mo.

Tonganoxie is a city of 1,000 population, located in the south central part of Leavenworth County, Kansas, about 30 miles west of Kansas City. It is located in an agricultural district, where several years ago the farmers realized the value of devoting time to the development of the dairy industry and, as a consequence, Tonganoxie has become a milk center. It now numbers as its chief industries three creameries and one milk condensery.

When the original water works system was constructed in Tonganoxie, drilled wells were constructed as a source of water supply, but as the water works system came into general use the wells became inadequate, so that about three years ago the city officials realized that the drilled wells would not serve the purpose. It was then proposed to construct a large dug well. Opposition was encountered on the part of the State Sanitary Engineer and on the part of the Engineer for the Public Service Commission, both of which bodies must approve the plans; the one that the improvement be authorized at all and the other that the city might be empowered to issue bonds to finance it. However, this opposition was overcome and a large dug well constructed.

The growth of the water works system and demands on the source of supply soon over-taxed this well and the city officials made a small drift into the water bearing stratum and found an appreciable increase in water produced.

During the summer of 1926 the demand for water by the Franklin Condensery and the construction of a sanitary swimming pool so increased the consumption that additional supply was absolutely necessary. Previous experience led us to believe that a large dug well with a horizontal drift near the bottom would produce the best results. A well was designed with a clear diameter of 6 ft. through the over burden of clay a distance of 25 ft. This material was removed and the hole cased with segmental sewer blocks laid in Portland cement mortar. Under the over burden was the water bearing stratum, a gray sand stone. There was not sufficient head on the water to overcome the percolation friction and rise in the hole. The hole was carried down with a diameter of 6 ft. for about 2½ ft., a distance considered safe to begin to widen out. The diameter was then gradually increased to 10 ft. and the hole carried down. At about 84 ft. the underlying limestone was reached and the horizontal dirfting started. It was intended that the drift be 6 ft. high and 4 ft. wide, but in fact, it was nearer 6 ft. square, or larger. During construction it was necessary that pumps be kept running to keep the water level down so we could work. The drift was finished back approximately 100 ft. and the pump, a centrifugal of 300 gals. per minute capacity, was taxed to the limit to keep the water down.

When the drift was completed, the workmen, as they left the drift, perforated it with holes, using a jack hammer drill. Upon completion of the well a 300 gal. per minute Pomona deep well pump was installed, and the well has been found to produce 250,000 gals. per day without difficulty.

When the well was completed, bids were asked, but none were received. Finally the city undertook the work and carried it out on a force account basis. The work was completed for just about the estimate, which was as follows:

Digging and casing

first 25 ft.	$18.65 per ft.
Digging 25 to 40 ft.	23.65 per ft.
Digging 40 to 75 ft.	30.00 per ft.
Digging 75 to 90 ft.	40.50 per ft.
Drift	20.00 per ft.

The city is highly pleased with the results of the work and much of the credit is due to the attention given the matter by the Mayor, William Heynen, and his knowledge of conditions, gained by contact with the water system from its inception.

THE ENGINEER IN POLITICS

By George H. Dern, Governor of Utah

(From "Engineers and Engineering" for October, 1926)

If the engineer is to go into politics, as I think he should, I believe the curriculum of every engineering school

should be amended to include a good stiff course in public speaking. My observation has been that the engineer in private conversation can scintillate as brightly as a life insurance agent or an oil stock salesman, but before an audience, with rare exceptions, he is a total loss. He will not get up and talk. He hides his light under a bushel, and sits on the bushel as dumb as an oyster. I have attended meetings at which some topic of general interest to the members was up for discussion, and where an animated debate was the logical thing to expect. After the chairman states the subject and invites discussion, there is dense silence. Finally a member, bolder then the rest gets up and, with trembling voice and knees, makes a motion. The motion carries, the meeting adjourns, and then the members gather into groups and begin to discuss the question seriously and intelligently, giving cogent arguments on either side and embellishing their remarks with appropriate or inappropriate epithets, illustrations and figures of speech.

Now, I am not pleading for more speechmaking. The good Lord knows we have too much of this great American indoor sport already. But I think every man ought to be able and ready to express his opinions at the proper time. Some men have a reputation for wisdom because they do not talk much. We speak of the wise old owl because she never speaks, but in my opinion the owl's reputation for wisdom is vastly overrated. Silence is more apt to be a cloak for stupidity than for wisdom. The person who has ideas cannot exert any influence by keeping them locked up in his own mind. The great motive force of the world is not muscle, but ideas, and ideas in order to get in their work must be released.

The engineer, with his training of observation and analysis, ought to and does have ideas, and usually they are sound because they are founded upon facts and are carefully reasoned out. The world needs his ideas, and he ought to be equipped to express them at the time and place where they will do the most good. Perhaps I am presumptuous in urging engineers to be more vocal, but I think this recommendation has a direct bearing on my subject.

Politics is the science of government, and government is the science of human relationships. In other words, politics has to do with people. So long as the engineer remains in his own profession he has to deal almost exclusively with things —with inanimate matter. I was going to say cold, inanimate matter, but as a matter of fact inanimate matter is not always cold, as smeltermen and electricians know. But when he gets into politics he has to deal with living, breathing human beings. He must know something about how the human mind operates. He finds he cannot do anything for the public unless the public believes in him. He must sell himself to the public before they will follow his lead.

This is an age of specialists, and since engineering and politics are concerned with such different kinds of materials, it has come to pass that engineering is one specialty, and politics is another, and it is only occasionally that the engineer, in a dilettante fashion, becomes active in politics. Possibly that is the first reason why the engineer in politics is conspicuous by his absence.

I attended a meeting of the Engineering Council of Utah the other day, at which 200 engineers were gathered together, and as I looked over that company, I saw few who would know what to do if by chance they should get into a primary or a convention. All of them were highly intelligent and highly educated, but they were innocent babes when it came to playing the gentle game of politics. The reason is that they do not play the game. It takes practice to become proficient in politics just as it takes practice to become proficient in golf.

Why doesn't the engineer participate in politics? I suppose one reason is that he is too busy trying to make a living, and the fees in politics are not overly tempting. I am afraid, therefore, that I should be giving engineers bad advice if I advised them to go into politics for the money there is in it. However, it is well known that engineers do not care anything about money. All they want is a chance to serve their fellow man, and so I feel safe in urging them to go in for politics.

STATEMENT BY AMERICAN CONSTRUCTION COUNCIL

By Franklin D. Roosevelt, President, 28 West Forty-Fourth St., New York, N. Y.

The American Construction Council in its national survey of construction conditions recently made, reports healthy activity in the building industry generally. The volume of operations points toward as great a total for the present year as for 1925, although there has been a slight

seasonal recession and the situation is somewhat spotted in various parts of the country. The amount of work scheduled and contemplated for winter operations is very favorable.

The character of operations is of a much more substantial type than that of the past few years, showing an increased demand for better built and properly financed buildings which the American Construction Council has been advocating so strenuously since the setting in of the building boom in 1922. This is by far the healthiest situation that has existed in the building industry for some years as there has been a very noticeable recession in new speculative building not backed up by adequate values, and a better class of business is coming upon the market.

The slowing down in housing construction further reflects a favorable trend, with an increasing demand for a higher class of apartments and hotels and of suburban homes, the need for which the Council emphasized during the peak period of indiscriminate house building the past few years.

Building operations in general show a larger percentage of structures for commercial and industrial purposes, public buildings and public utilities. There is a better supply of rentable space of good quality.

Material prices and labor are reported fairly well stabilized with no apparent indication of any radical change in the near future. Labor productivity is increasing.

Contracts for engineering construction show a very substantial increase over the first ten months of last year with equally favorable prospects as to proposed work.

Highway construction has been very active, the main obstacle being the lack of stable financing which would permit a continuous road building program in some states. Some of the trunk line railroads report the greatest capital expenditures on construction for a number of years with a corresponding amount of projected work.

In general the reports favor the probability of well sustained business in all branches of the construction industry for some time to come. Some persons, however, urge caution along all lines of building operations except what is necessary for private use to meet the needs of industry in growing districts, feeling that this will help make for stability of values.

The great need continues for better conceived, better financed and better built buildings, accompanied by intelligent city, town, and community planning, not only as to building proper, but also with regard to traffic conditions and health hazards. The public can now get, and should insist upon getting, full value for every dollar it puts into building. It should also insist upon getting similar values for the money it puts into highway construction, which means that it must demand not only better highways of first-class construction, but also stabilized highway building programs so as to permit economical construction.

ALABAMA'S ROAD PROBLEM

(Editorial in "The Bond Buyer.")

An editorial in the Montgomery, Ala., Journal on "Fallacies of Bond Advocates" strikes us as good common sense. Three candidates for Governor are running on highway bond issue platforms, the amount of the issues favored being $25,000,000, $35,000,000 and $75,000,000. Creation of additional State debt in these amounts would increase the debt to assessed valuation ration to 6.41, 7.34 and 11.8 per cent respectively. Bond buyers, the editorial points out, do not ordinarily care to bid on State bonds when the ratio gets above 5 per cent.

The experience of North Carolina is cited by bond advocates as a striking example of the wisdom of issuing millions of dollars worth of securities to pay for fine highways. But, the Journal replies, the difference in the wealth of Alabama and North Carolina should be a convincing reason why Alabama should not blindly attempt to follow Carolina's lead. While this it not a conclusive argument against borowing on a scale in keeping with Alabama's ability to carry the burden, it is a proper answer to the bond issue enthusiast who too often justifies his schemes by comparisons that are utterly misleading and ridiculous.

Alabama's completed highway systemt will cost, it is estimated, $80,000,000. A good start has already been made with the issuance of bonds which are being taken care of nicely by revenues derived from special taxes on the users of the roads. If a second $25,000,000 is clearly needed for aditional roads, why not vote the bonds and reserve judgment on the third authorization until the wisdom of the earlier investments in roads is established?

COST OF SUBGRADE PREPARATION, MIXING, LAYING, FINISHING CONCRETE HIGHWAY PAVING

By L. F. Collignon, McCarthy Improvement Co., Kahl Bldg., Davenport, Iowa.

(Paper read at 1926 meeting of Illinois Association of Highway and Municipal Contractors.)

Quite a few years ago a Chicago contractor published his detailed cost data in an engineering journal and the observation was made by some contractors that is required a great deal of courage to broadcast such information to competitors. However, at most of the highway lettings in Illinois and Iowa. during the last year or two there were astonishingly low prices submitted and after each letting it was not unusual to have the low bid commented upon and analyzed by the other bidders. After hearing many of these it would appear to be the consensus of opinion of most contractors that what a competitor knows about the costs of others is not nearly so important as what he apparently (in the others, opinion) does not know about his own.

It is safe to assume that all contractors who operate with ordinary efficiency have similar costs on such work as subgrading, material hauling, handling material, and mixing and laying paving, provided they meet with average conditions of soil and weather. The difference in bids arises not in the direct costs of labor, but in assumptions as to cost of owning and keeping up equipment and over-optimism in assuming that the most favorable conditions ever met with before can be expected on all future work.

Now while the direct labor cost of different contractors on subgrading, and mixing and laying concrete and various other operations will be very similar for all operating with ordinary efficiency where conditions are the same or where costs over a long period are compared, they will be far apart on most small jobs because conditions vary so much. A job of five or six miles might in some instances be completed in two or three months with not over three or four days rain each month. A contractor using his cost figures made up from such experience can perhaps easily land more work, but he will not be likely to meet those conditions twice in succession. Instead, he may have a month or two averaging four or five working days only. The only costs that are of any use and safe to base a bid on are average costs over a period of a year or more.

The basis for cost data given here is work done in Iowa in 1924 and in Illinois in 1925, and covers about 23 miles of our work, on which the hauling equipment was trucks.

For the purpose of getting a definite figure on cost of depreciation and repairs of equipment, together with other expense incidental to owning equipment, I have used the data compiled by the A. G. C. committee appointed for that purpose. They represent a fair average cost and are more familiar to contractors generally than any other cost figures.

Average work per season, per mixer, based on thickness of Illinois standard paving, was 123,000 yds. Direct labor cost of subgrading and rolling was 9.4c per sq. yd. Cost of depreciation, repair, taxes, storage of roller, tractor, subgrader, and scarifier, based on costs compiled by the A. G. C. was $2,850 per year, per outfit, which amounts to 2.3c per sq. yd. Fuel and oil cost on the equipment was 0.4c per sq. yd. Summarizing these we have for subgrade preparation:

Direct labor subgrading and rolling	9.4c
Cost of owning equipment and up-keep on same	2.3c
Fuel and oil	0.4c
Total	12.1c

Now our direct labor is not at all times as high as 9.4c. There are many days that costs do not exceed 5c, and there will be miles of subgrading costing not over 7c, especially during summer, but costs mount when a stretch of rainy weather is encountered, or where soil conditions slow up operations on subgrader or mixer. A proportion of superintendent and field office expense is also included in the labor item.

The season of 1924, according to our record, permitted work on 98 days only. The season of 1925, one of the most favorable we have had, gave us 110 working days. Many a day $50 or more is expended, draining subgrade or other similar work, with no progress in getting the paving laid. During a period of about ten years over which we kept a record, the average number of days for pouring concrete was less than 100 days. Straight time men draw pay for more than twice that number of days.

Cost of setting forms, mixing, laying and hauling concrete, handling steel and center strip and curing with calcium

chloride, averaged 15.2c per sq. yd. for direct labor. Cost of owning equipment, including depreciation, repairs, taxes, insurance, etc. according to report compiled by the A. G. C. is $10,950 per outfit per year. The equipment included is mixer, pump, forms, water pipe and form grader. Cost per sq. yd. for equipment therefore is 8.9c. The fuel and oil cost 1.4c per sq. yd.

Summarizing we have the following:

Direct labor on forms, mixing, placing and finishing paving	15.2c
Cost of equipment, including depreciation, repairs, taxes, etc.	8.9
Fuel and oil	1.4c
Total	25.5c

What was stated regarding the subgrading applies also to the mixing and laying costs. They are not those experienced during favorable seasons or under ideal conditions, but they are average costs based on conditions that are met with in the long run.

When the figures of the A. G. C. Committee covering equipment costs are compared to costs of repairs and depreciation kept by contractors over a long period, they will be found to come surprisingly close. To the cost of equipment on subgrading and mixing and finishing paving as given above, totalling 11.2c per sq. yd., add the equipment required for all other operations, excluding however, hauling equipment which should be figured separately. It is safe to say that no contractor averages less than 10 to 12c per sq. yd., as his cost on equipment, depreciation, repairs, taxes, insurance and incidental expense. And that expense is incurred and that much comes out of the contractor's pocket, for every yard of paving laid regardless of the fact that a contractor may shut his eyes to it for a year or a few years. A few years ago I heard an Iowa contractor make the statement that he had paid for his equipment and that he didn't need to figure any equipment cost for the next few years. In other words, he believed that having been fortunate for a few years, he could afford to donate the use of his equipment for a similar period. Statistics gathered by insurance companies indicate that approximately 95 per cent of business ventures eventually end in failure. They do not show how many of these failures are contributed by the contracting business, but it is certain that of those who have fallen by the wayside, a great many have done so because of their failure to realize the importance of equipment cost.

In connection with this there is a paragraph of an address delivered recently by R. H. Towner before the Surety Underwriters Association, in which some of the more conspicuous failures are named. He states: "Every contract bond underwriter who remembers the names of the big contracting firms that he bonded 10, 15, 20 years ago, can recall a long list of them that failed on some huge undertaking, causing surety companies a tremendous loss. Norcross Brothers; MacArthur Brothers; Larkin & Sangster; Fraser, Brace & Co.; John Pierce; George W. Jackson; Ellmore & Hamilton; Shanley-Morrison, Inc.; Wm. Bradley; Terry & Tench; Degnon, and a host of others. They failed and their places are being taken by new men." And every one can add a long list of his own of contractors who have come and gone during the last 10 or 15 years. The concerns named by Mr. Towner did not apparently suffer from lack of capital. Errors in estimating and judging costs must account for most of the failures.

Euipment constitutes by far the greatest part of a contractor's capital, therefore, it is one of the most important in figuring the cost of subgrading, mixing and laying concrete, as well as of any other operation in the course of laying paving, and one that may be most easily overlooked. But if the cost is consistently overlooked, like with those included in the list of failures cited above the consequences are certain failure.

PLANNING STATE HIGHWAY SYSTEMS

By J. G. McKay, Chief, Division of Highway Economics, United States Bureau of Public Roads, Washington, D. C.

(From "Public Roads" for November, 1926.)

The last 15 years have seen the reemergence of highway transportation, one of the oldest methods for the movement of people and goods, from the position of comparative unimportance to which it had fallen during the period of greatest railroad development to a position of the first rank in the national scheme of transportation. Mass movement of people and commodities on the principal routes of the various State highway systems confronts us as a fact and not a theory.

The general field of motor-vehicle transportation can be divided into three major

classes of service. First is the local distribution of commodities and local transportation of people. This service constitutes in tonnage the bulk of the motor truck movement and is primarily the distribution of goods within cities and their suburban areas. In Connecticut 67.1 per cent; in Ohio 64.2 per cent; and in Pennsylvania 77.3 per cent of the net tonnage transported by motor truck is hauled less than 30 miles. Seventy per cent of the net tonnage hauled in Cook County by motor truck is a direct distribution of commodities to points of final use. In passenger transportation the principal function is also mass transportation within local areas.

The second principal class of motor-vehicle service supplements existing rail and water service by extension of freight and passenger service into areas not served by rail or water lines; substitutes motor vehicle service for rail operations of unprofitable branch lines; and provides a combined service in conjunction with railroads or boat lines or both. The primary function of the motor vehicle in this joint movement is the movement of people or goods in the short haul.

The third class of motor-vehicle service is the so-called long-haul transportation. This type of service is not important as to quantity of movement nor would it appear to be economically sound. For motor trucks, at least, the volume of tonnage in the long-haul zone is comparatively small and decreasing in importance. In Connecticut 15.2 per cent; in Pennsylvania 6.9 per cent; and in Ohio 15.9 per cent of the net tonnage is hauled over 60 miles. Usually long-haul transportation is limited to movements in which speed of delivery or some special characteristic is the principal determining factor.

A relatively small percentage of motor trucks are engaged in the commercial transportation of freight. On the Maine highways 8.7 per cent; on the Pennsylvania highways 13.6 per cent; and on the Ohio highways 21 per cent of the loaded trucks are commercial, operating either for hire or on contract.

Analysis of motor truck transportation in the several States shows that the development of a large system of motor trucking over a considerable area beyond the short-haul is economically unsound. The movement out of cities is primarily a local process of distribution. The movement toward cities consists largely of goods produced in the area, principally food products. The volume of goods moving between two shipping points is unbalanced in the short-haul and progressively unequal with increase in distance. This fact negatives the development of long-haul motor truck transportation as a system of haulage.

The cost of providing motor-truck common-carrier service increases with increase in distance, owing primarily to the increasing terminal cost ratio to total net revenue, return movement of empty trucks, and partial loads at full rates or full loads at low rates.

The principal function of the motor vehicle as part of a correlated system of rail, water, and highway transportation, as indicated by present trends, seems to be its development in the short-haul zone with great potential possibilities of volume service in terminal areas of dense population.

The functional relationship of the motor vehicle and water transportation would appear to be the transfer of goods to and from docks and the mechanical organization of motor truck loading and unloading methods in the water shipping area to facilitate rapid loading and unloading of cargoes.

The principal service of the motor truck as a part of the organized rail transportation is primarily in the rail freight transfer areas and in the short-haul movement of rail package freight. Whatever we may think of present motor vehicle operating methods, if there is a real demand for this type of service it will continue to develop. The problem lies in the intelligent organization, improvement and control of this new type of transportation. Probably the next few years will see the organization of large motor vehicle operating companies functioning as a part of existing rail and water systems or as independent operating companies. Since the haulage of goods and people can be generally safeguarded by regulatory legislation, it would seem that present rail or water lines should qualify as the responsible financial and experienced agencies of mass transportation of people and goods in this rapidly developing field of motor vehicle transportation.

Meanwhile, no matter under whose guidance the organization of motor vehicle operation is developed, there remains the present problem of intelligently planning highway systems to serve this rapidly growing method of transportation.

Planning the Improvement of Highway Systems

There is no fundamental difference in principle between the public business of developing systems of highways, and private enterprises engaged in producing commodities or in the performance of services. For example, light and power, gas and telephone utilities and other industries are all engaged in the production of their commodities for public use. The history of their modern development and expansion is largely a development based upon a careful analysis of the demand for their product by present and potential consumers in a given area. The soundness of their analysis of the need for new service and the expansion of their plant anticipating the demand for their product has been an influential factor in the progress or lack of progress of many communities.

The same basic economic and engineering principles of management that exert such a controlling influence in the field of private business should govern the public business of production in the highway field.

Applied to the public business of a State responsible for developing a connected system of improved highways to facilitate the transportation of people and commodities, the first basic principle of production management is that the various sections of a highway system selected for improvement and the type of improvement chosen for each section should be based upon present and expected future traffic demands, modified by the various physical and economic characteristics which affect the choice of specific construction types to be built on the various sections of a State highway system.

The second principle is the familiar one of the budget upon which all financially sound industries operate. Applied to the highway business it involves; (1) the determination of the amount of money required to complete the improvement; (2) the apportionment of the cost among those who benefit from the improvement of the highways, and provision through necessary legislation for raising the required highway funds. This management must insure the expenditure of the money in accordance with a predetermined plan of improvement in which each route or section of a route is to be improved to the degree required by the traffic and to no greater or less degree. The raising of revenue is the responsibility of the State legislature, and is always the final limiting factor in any program of public works. Provision by a legislature of more than the necessary revenue is apt to encourage waste; provision of sufficient funds, well managed by the highway department results in a well-balanced system of highway improvements and the economic development of the State as a whole; provision of insufficient improvement funds defers the true improvement of a highway system, forces the highway department to spread uneconomically its expenditures of State funds over the entire State system, usually results in the development of a highway system below the requirements of traffic, and, if continued over a period of years, increases the total ultimate cost of highway transportation.

The establishment of scientific plans for highway development, which will result in the maximum of highway improvement and highway transportation service, with available revenue, labor, equipment, and building materials, requires a careful analysis of highway traffic, the trend of its development and its distribution over the highway system. The necessity of such an analysis is now recognized by highway executives, but their efforts have been handicapped by lack of precise knowledge of the character and amount of present and expected future traffic using the various sections of the system.

The plan of State highway improvement may materially alter the economic and social development of a people as a whole or any section thereof. The location and improvement or lack of improvement of a given route is of vital importance not only to the traffic of the immediate locality, but also to the traffic of larger areas. Therefore, the development of a stystem of highways should not be judged as miles and types of highways constructed each year but considered in terms of the movement of people and goods. The planning and construction of a connected system of highways deal in fact with the destiny of localities and States, their agriculture, their industries, the growth of suburban areas adjacent to centers of population, and the social activities of a people. This is a tremendous social responsibility and not merely a problem of physics concerning mixtures of cement, water, brick, steel, bitumens, stone aggregate, gravel, equipment, and labor into what we now term the modern road.

Whether to Improve and How Much the First Questions

The major problem is not one of the particular type of materials to use, but rather whether to build or not, and how much highway service should be furnished in a given area. Upon the proper solution of these problems depend the well-being and progress of a people. Considering the improvement of highways from this point of view there can be no question concerning the necessity of developing sound plans for highway improvement over a period of years in the several States, and of providing the necessary money to carry out economically the proposed plan of improvement.

The principal classes of highway improvements are: (1) New construction (2) stage construction, (3) reconstruction, (4) building of bridges and culverts, (5) highway and railroad grade separations, (6) widening of present highways, and (7) method of guiding and safeguarding traffic.

Each of these classes of improvement, although more or less distinct as a class, is part of a general scheme of betterment, and especially within congested population and traffic areas the highway engineer faces the urgent need of solving all these complicated problems of highway improvement. The development of the plan as a whole, including each of the several classes of improvement, should be based largely upon present and expected future traffic and "lay-out" and condition of the existing highway system in any given area.

The first step in planning a program of highway improvement is the measurement of the present, and the prediction of the future volume and character of traffic on the State primary, secondary and tertiary systems. The principal traffic factors involved in judging the relative traffic importance of the three systems, or sections of each system, are the average daily and maximum total traffic, and the average daily and maximum truck traffic using each section. The average daily number of loaded light (one-half to 2½-ton), medium (3 to 4-ton) and heavy (5 to 7½-ton) vehicles is an important factor in the determination of the plan of improvement as well as in the selection of the types to be constructed.

The second step is the determination of the relationship between population and demands for highway service and the consideration of present density of population and population trends as an aid in the development of a plan of improvement which will most efficiently serve the traffic needs of this population.

The next step is the classification of the various highways or sections of highways as major traffic routes (class A), secondary traffic routes (class B), and minor traffic routes (class C). A class A highway is defined as one that requires one of the so-called rigid types of improvement, concrete, brick, bituminous concrete, or their equivalent. A class B highway is defined as one that requires a so-called flexible type of improvement, such as standard bituminous penetration macadam or its equivalent. A class C highway is defined as one that requires other lesser types of improvement.

The principal traffic factors involved in such a classification are:

(a) Average daily and maximum total traffic and truck traffic.

(b) Forecast of average daily total traffic and truck traffic for periods of 5 and 10 years.

(c) Average daily and expected future number of loaded light, medium, and heavy trucks for each route or section of route.

(d) The ratio of the total number loaded trucks to the total traffic in order to separate for special consideration routes or sections of routes on which motor trucks are an abnormally large or small proportion of total traffic.

(e) The number and frequency of critical heavy loads.

(f) Average maximum traffic as one measure of the width of the improvement, the necessity for improvement of additional parallel routes and the "by-passing" of congested centers of local traffic.

(g) Analysis of highway maintenance and capital costs and vehicle operating costs as an important factor in determining the traffic limits for the various types of improvement.

The fourth step is the measurement of motor-vehicle mileage on the primary, secondary, and tertiary highway systems, and the estimate of the earning capacity of these three systems to determine the relative vehicle-use value of each as a guide in developing the plan of improvement and the budgeting of construction and maintenance funds.

Finally, we must have a thorough analysis of the present system and the physical condition of the existing improvements on it, since the plan of betterment must, in general, incorporate

the existing State highway system as the basis of the improvement plan.

Special Consideration Necessary for Highway System Adjacent to Cities

A State plan of highway improvement can be separated into two distinct planning phases.

The first is the general State plan, consisting of a connected system of primary, secondary, and tertiary routes serving each section of the State. It should be recognized that just as there is a considerable variation in the present and expected future volume of traffic on the highway systems of the different States, so there is within each State also considerable variation in the present and expected future traffic on the various sections of the primary and secondary system.

The second phase of the State plan is the special consideration necessary in areas adjacent to centers of population. The improvement plan of the State and the plan of improvement of the larger cities within it should be worked out co-operatively.

This co-operative planning is essential to the proper location and entry of State routes into congested traffic areas, to avoid dumping traffic from one or more than one State route into an already congested area, to provide for adequate connections and improvement of the city streets that join State routes at city limits, to make provision for "by-passing" congested traffic areas, to eliminate obstructions to the easy movement of traffic, and finally to provide belt, arterial, and secondary local traffic routes to facilitate the rapid, safe, and unobstructed flow of traffic in congested traffic areas.

In the final analysis the worth of a transportation survey and the resulting plan of highway improvement is measured by the actual highway construction, reconstruction and widening program which is carried into effect over a period of years.

The State highway engineer, as the executive director of the public business of providing highways, is responsible (1) for the analysis of the traffic demand for his product on the various sections of the State system; (2) for a financial analysis of the yearly cost, the revenues required, the funds available, and for the establishment of a budget for the period of the improvement program; and (3) for the business and engineering management of the improvement program.

The major limiting factor is the financial program set up by the legislative organization responsible for raising the revenue to give reality to any plan of highway improvement; and therefore a large part of the responsibility for the character and condition of a State system of highways rests upon the department of the State government responsible for the raising of highway funds and not upon the department charged with the duty of constructing the highways.

RESULTS OF FIVE YEARS OF STATE ROAD BUILDING IN NORTH CAROLINA

By Frank Page, Chairman, State Highway Commission, Raleigh, N. C.

(A statement made by Mr. Page in hearings before the Interstate Commerce Commission on interstate operation of motor trucks and buses, I. C. C. Docket 18, 300.)

The building of our state system of highways in North Carolina during the last five years has linked together our great trunk-line railroads and our waterways into an effective transportation machine.

On the coast our ports receive imports from all the world distributed to our Carolina markets by rail and motor. A coastwise shipping takes potatoes, melons, and truck produce to Baltimore, Washington, and New York.

Our trunk-line railroads take our fabricated tobacco, cotton, and furniture from the factories of Gastonia, Durham, Winston-Salem, and High Point and deliver them to all parts of the United States and other countries.

Our 6,500 miles of state highway system—4,500 miles improved plus the secondary feeder roads—are the means by which much of the raw materials get to the factories and thence to the rails. Conversely they are the means of distribution of our imports and food products to our people.

In this period of five years from 1921 to 1926, North Carolina has probably made greater progress agriculturally, industrially, and socially than any other state in the union in a similar period of time.

One of the most important factors in the metamorphosis has been our highway improvement program, involving the building of $125,000,000 worth of highways since 1919—most of it since 1921 when we issued $50,000,000 in bonds and

later $35,000,000 more to build a state system of highways.

What has been the result? Has it helped or hurt industry, agriculture, the taxpayer, the 4,000 miles of trunk-line railroads and 1,000 miles of short lines in the state?

A few facts will help us to understand what has happened since 1920 and 1921.

We have increased the number of our farms by 13,000 during a period when the number of farms for the country as a whole fell off.

We have built consolidated rural schools valued at $35,000,000. To these each school day are brought 100,000 pupils in 2,000 school buses operating 40,000 miles—largely on the state system.

We have developed 40 co-operative farm marketing associations, many of them stimulated by our state Department of Agriculture, and engaged in shipping carload after carload of poultry, eggs, hogs, fruits, and vegetables that we formerly never grew for outside sale.

Roadside markets and city curb markets have stimulated the growing of truck produce on our farms and are the outlet for the ram surplus. The farm women are the merchandisers of this surplus and with the first available cash money most of them have ever had are putting modern conveniences into their homes, dressing themselves and their children better, painting their houses, and beautifying their yards.

We have recovered our lost provinces—those sections of the state to the far east and west formerly foreign to the state so far as transportation connections of any kind were concerned. To reach some of these points in our own state involved rail travel through one and sometimes two adjoining states. Our highways were out of the question for travel to these places. Today the roads have gone through and we have put every part of the state within reach of every other part—almost from sunrise to sunset over the state highway system.

The state of North Carolina has taken the lead in spindle hours operated by cotton mills.

The true value of our property has multiplied eight times since 1900 while the entire country was increasing the true value of property by four times.

The question may arise as to how far the highways can be credited with bringing this about. Let us analyze the situation further.

How Was Highway Improvement Accomplished?

We have built our state system and are maintaining it entirely at the expense of the road user.

There is no state property tax for highways. State highway moneys come from three sources—bonds, motor registration fees, and gas taxes. The bonds are issued serially and are retired through a sinking fund maintained entirely by the motor taxes.

In 1921 the state legislature established a state highway system, 6,500 miles in length and tapping every county seat and every town and city of importance. The state is now maintaining 6,200 miles of road—all but some 300 miles of mountain trails. The roads first improved were naturally those between the cities because communication between them was necessary before tying in the more remote parts of the state.

North Carolina is predominantly agricultural, with manufacturing centered in the Piedmont section around Durham, Winston-Salem, Greensboro, Charlotte, Gastonia, High Point, and Raleigh. Our highway system makes our industry and agriculture interdependent—each supplying the other. The lumber for our furniture factories, cotton for the cotton mills and tobacco for the great factories at Durham and Winston-Salem are produced within the state and move both by rail and highway at the beginning and end of fabrication.

Influence of Highway Improvement on Agriculture

In 1925 there were 283,491 farms in North Carolina with nearly 7,000,000 acres under cultivation. This cultivated area represents about 27 per cent of the area in farms and about 23.5 per cent of the taxed area of the state.

The three leading money crops—cotton, corn, and tobacco—occupied 72 per cent of the cultivated area of the state, and with grain and hay constituted 92 per cent of the cultivated area.

Diversification, however, is becoming more popular and improved highways now make available the markets for the products of diversification. Some 40 co-operative farm marketing associations, mostly organized since 1920, with the excellent aid and advice of the state department of agriculture are the medium of much produce selling. With the exception of the farmers' federation at Asheville it is doubtful if any of them operate their own trucks. Roadside markets are

fast becoming a factor in disposing of farm surplus products.

William A. Graham, state commissioner of agriculture, stated:

"The good roads in this part of the state have made it possible to supply the manufacturing cities from farms located as many as 40 miles away or farther. Prior to the advent of good roads the farmer who lived as much as 10 miles from town rarely took produce to market unless his roads were in what he would call prime condition, and then it took him an entire day to make the trip.

"The town was then forced to get its supplies from sources outside the state, as it could hardly draw on more than 75 square miles of territory for local production. With the coming of good roads the market gardens of the cities have grown from the former area of 50 to 75 square miles to 1,000 to 1,200 square miles or more. Here we find diversified farming—cotton, corn, tobacco, potatoes, wheat, oats, and vegetables—all growing on the same farm the same year."

Mr. Graham's statement forecfully illustrates the very large intrastate movement of produce from farm to city and of manufactured commodities from city to farm in return, almost entirely by motor truck.

The total value of North Carolina crops last year was $320,000,000.

During the year 1925 North Carolina truckers shipped to points out of the state 15,555 carloads and 490,000 express packages of truck, which brought nearly $12,000,000 direct to the producers.

The highways have been the medium for no small amount of new agricultural tonnage reaching the rails. This is particularly true of poultry and hog shipments. In 1924 we shipped out of North Carolina 464,285 pounds of poultry, in 1925 some 750,000 pounds, and in 1926 (year ended June 30 in each case) the total reached 1,900,000 pounds, 250 per cent more than the 1924 figure.

As to hogs, in 1924 there were shipped 23 carloads, in 1925 this increased to 58, and in 1926 to 80 carloads, or more than three times the 1924 figures. Just the other day one of our state college men told of seeing 32 farmers receive a check for $11,000 covering the shipment of eight cars of hogs they had brought in to three rail-shipping points by motor truck.

Shipment of eggs in 1924 totaled 6,681 cases and increased to more than 8,000 cases in 1926.

Dairying.—The State has lately turned strongly to the possibilities of dairying. It goes without question that highway improvement has been quite largely responsible for getting large quantities of milk into our southern cities. The larger ones show an increase of 250 per cent in milk consumption.

Nine of the principal cities of the state now pay farmers of surrounding sections $4,178,520 annually for milk. Incidentally, this supply has been developed and handled almost entirely over the highway so that the railroad has not entered as a competitive transportation factor.

The highways have assisted in the establishment of milk plants. John Arey, of the state college, reports the establishment of seven milk plants in the state since 1920. There were but five at that time. There are now 15 creameries making butter, seven of them also established since 1920, with others now under construction.

Some 7,500 farmers sell cream to these establishments with an annual butter production of 2,000,000 pounds.

Fruits and Vegetables.—The United States Bureau of Agricultural Economics reports car-load shipments of fruits and vegetables out of North Carolina for the five-year period 1921 to 1925, inclusive, as follows (some of the smaller lots are not included, which accounts for the difference between this total and one previously given for 1925):

There is of course evident the effect of

CAR-LOT SHIPMENTS OF FRUITS AND VEGETABLES FROM NORTH CAROLINA

Crop	Year 1921	1922	1923	1924	1925
Apples	77	384	220	433	344
String beans	128	219	261	559	459
Cabbage	251	213	364	263	371
Canteloupes	894	700	620	401	655
Cucumbers	641	687	1,175	1,639	1,562
Lettuce	445	622	718	714	537
Mixed vegetables	66	326	758	1,093	853
Peaches	594	1,452	215	1,657	2,024
Spinach	2	5	25	21	11
Strawberries	503	1,101	1,668	2,046	1,634
Sweet potatoes	982	721	654	720	1,189
Tomatoes	1	.....	.....	8	.....
Turnips and rutabagas	6	9	5	2	3
Watermelons	1,657	993	1,542	664	991
Potatoes	3,071	4,202	3,475	6,566	4,052
Total	9,318	11,634	11,700	16,786	14,685

crop and market fluctuation, particularly in potatoes in 1924, but the sum total has been steadily increasing. Much of this tonnage moved to rail points over the highways. Some, particularly the potatoes, moved by water to rail shipping points. Each year, however, a greater percentage of certain crops comes by motor truck from longer distances to rail-shipping points.

Peaches.—The sandhills of North Carolina produced an enormous crop of peaches this year. Unfortunately the Georgia crop was a little late so that our peaches got into the northern markets about the time theirs did, depressing the price to all producers.

Here the highways were of considerable value, not so much in the car-loading of peaches as in the distribution of the surplus throughout the state. The truck was a safety valve, which handled the equivalent of 100 carloads or more of the grades which could not be shipped by rail. These went by truck direct to home markets. Another 10 to 15 carloads were shipped by rail to other cities in the state and from there marketed by truck.

Five years ago the peach growers would have taken their loss, for the highways were not there to help them dispose of this grade of peaches. And too, the rails did not lose the business, because most of these peaches were too ripe to ship by rail.

Roadside Markets Provide New Outlet for Diversified Production

At Hot Springs, N. C., there is a farm of 4 acres that two years ago, prior to putting through an improved road, produced little more than enough to support the farmer and his family who lived on it. This year they have not only lived well on it, but have cleared $2,200 in cash by marketing at their front gate the fruit and vegetables they produced.

Another farmer, operating a farm of 200 acres at Awanonoa has been clearing $25 a day for the summer and fall from the surplus produced on his farm. Here the market has no attendant but is conducted on the honor system and the owner claims never to have lost a cent. Prices are indicated and the buyer makes his own change.

Another farmer in Alamance County daily brings his cream 56 miles into Raleigh and delivers it to a creamery.

In Anson County a farm woman is canning goods at the farm. She travels 12 miles with a horse and wagon over the improved highway and sells her canned goods at the curb market in Wadesboro. For 10 years prior to the bettering of this road she had not been in Wadesboro more than twice. Now with the first cash she has seen for years, she is buying clothes for herself and children and conveniences for the house.

We have now 29 curb markets in different cities at which the farmers last year sold nearly a quarter of a million dollars worth of surplus produce from the farm. Five years ago there were only two or three of these markets, and those only in the larger cities.

The roads around Rocky Mount, N. C., were improved a little more than three years ago. A curb market was established 31 months ago and to date has resulted in the sale of $32,500 worth of produce.

Another phase of this curb market development is the growth of community booths within them. In one of these booths, one farm woman sells $10 worth of cakes a week, another has cleared $150 this year on canned soup mixtures, while still another has made $520 from her garden and chickens.

Not the least of the advantages of these markets has been the social contact between the city and farm. Each has learned what the other is doing. The farm women use the receipts from their produce sales to buy conveniences for the farm home—clothing, books—everything they have wanted but could not get before for lack of funds. Incidentally, all these purchases make increased business for the railroads, waterways, and highways.

Highway Service and the Cotton and Tobacco Industries

Cotton.—Just now we are faced with an over-production of cotton with attendant ill effects. The doctrine of diversification is being advocated. Our cotton fields are small and the soil is adaptable to other products so that we have all conditions favorable to production. Marketing facilities exist in the co-operative associations holding out the buying power of distant markets; nearby cities have their curb markets and the highways are at hand over which both can be reached.

At present cotton can be moved at any time. The condition of the road plays little part except to cheapen the cost of hauling the raw cotton to the gin.

Tobacco.—The chief influence of the improved highway on the tobacco grower has been to change his marketing processes. Prior to this development there were usually one or two small tobacco

warehouses in each marketing town. The tobacco grower came to these with his crop, taking all of one day with his mule and wagon to get there. The next day was spent in arranging the tobacco in baskets, grading and sorting it on the warehouse floor and closing sales with the buyers who visited these towns. The warehousemen cleared all sales and were therefore the commission merchants.

The grower now loads his truck at sunrise, travels up to 40 or 50 miles, puts his product on the warehouse floor, sells it and is back home again the same day. The process of marketing is shortened and cheapened; fewer buyers are required; the grower is always sure of a market at the larger point at any time he chooses to go; and he gets a better price for his product.

The industries of the state use rail transportation predominantly. They do, however, make frequent and necessary use of the highways.

One instance shows the service the highways rendered one cotton mill company, where the rail haul was circuitous and a delivery point a half mile from the railroad was involved.

In May this year a manufacturing company at Concord, N. C., bought 100 looms from a firm at Newton, N. C. The distance is 65 miles by highway and about 72 by rail.

The manufacturing company contracted with a trucker for $650 to take the looms from Newton to Concord, handling five every 12 hours and working night and day.

To ship by rail it would have been necessary to ship the looms single deck for lack of skilled labor to store them double deck. The freight charges between the two points on this basis were $515, plus $300 for labor and trucking from the station at the other end of the haul to the plant half a mile away, plus certain unknown charges for blocking the looms in the cars.

The two state highways and one county highway involved in the movement by truck were thus worth $165 to the manufacturing company in this one instance alone.

Most of the raw materials come to the cotton mills by rail and most of their finished products go out by rail. The highway, however, permits them to draw on a wider supply of labor, principally from the farm.

The truck line past the door is a guarantee against delays in productions and shipment. A telephone call to a nearby city, perhaps 40 or 50 miles away, for 100 feet of leather belting or a few feet of pipe with orders to deliver to the truck line and the needed supplies are in the factory a few hours later.

The other day a mill received an order for immediate delivery of goods to be shipped in boxes of unusual size. None was on hand. Time did not permit of ordering for rail shipment. The order for the box shooks was placed by telephone; the shooks were picked up by motor express that afternoon 40 miles away and delivered to the factory the next morning. By that afternoon the order received 36 hours before was on the railroad loading platform.

One other service is given the mills by the highway and motor transport. This additional transportation is a guarantee against mill shutdowns or delays in filling orders due to uncertain or undependable rail service, car shortage, etc. Cotton warehouses maintain their own trucks and when a mill needs raw cotton urgently it is sent by motor truck. It costs more to send it that way, but this cost is offset by the mill's ability to keep running and meet consumer demands on it.

Cottonseed oil.—The cotton gins are usually located near the fields and several of them will supply one oil mill with seeds. Formerly the seeds were hauled to a rail siding or into town to the rail freight station when the gin itself was not on a siding. Now it is not infrequent to haul the seeds by truck direct from the gin to the cottonseed oil mill, thereby avoiding extra handling delays, etc.

Furniture.—The center of the furniture industry is at High Point and is served almost entirely by rail, both as to raw materials and finished product. One exception is worthy of note. At Asheboro and Thomasville in particular (nearby towns) many split, cane-bottom chairs are made. The cane bottoms are sent out as piece work by truck to farms and residences in the neighboring sections. As the work is completed the bottoms are gathered by truck, carried back into town for assembling and rail shipment from there to market.

The smaller cities in particular have felt the impulse to growth called forth by the improving of the highways connecting them with larger and more progressive cities. Now nearly all of them have new hotels, new business houses, municipal office buildings, paved streets, and better homes. Some of the larger cities show this growth more specifically.

Raleigh is now the trading center for 172,000 persons, 31,000 of these within the corporate limits and the balance within an area of 25 square miles. The city's population has increased from 24,418 in 1920 to 31,000 as of July 1, 1926. Building permits have increased from $862,322 in 1920 to $3,502,011 in 1925. There have been $17,000,000 worth of building in the last five years with the total assessed valuation for the city in 1926 given as $45,000,000.

The relation of highway to rail during this period is shown by a statement from Plate Collins, secretary of the Kinston Chamber of Commerce, October 23:

"Volume of shipments by rail has increased 20 per cent since 1923 in spite of the fact that a big part of short-haul freight formerly handled by the railroad now goes by trucks."

The Goldsboro Chamber of Commerce estimates "increase in business 25 per cent caused more and better homes both in city and country, increase in both mercantile and factory buildings."

From William T. Ritter, secretary of the Winston-Salem Chamber of Commerce, comes the following:

"Our retailers report a 65 per cent greater purchasing power per capita in our trade territory. The property valuation in our county has increased over $30,000,000 since 1921, and some $2,000,000 worth of homes are being erected by our citizens on areas located on the mail highways serving this city. The outputs of our industries as well as agricultural areas have shown tremendous increases since 1921, and there is no gainsaying but that the State's highway program is responsible in no small measure for this increased prosperity."

John D. Topping reports from Asheville, one of the resort centers of the state, for the past eight months of 1926 as compared with the same period for 1925:

"The dollar volume of business shows 45 per cent increase over 1925—204 per cent increase over 1919. The following figures show increases in 1926 over 1925; Bank deposits, 26 per cent; post office, 22 per cent; building permits, 42 per cent. Seven hundred residences inside the city and an equal number outside being built. Number of visitors increased 25 per cent."

The secretary of the Greensboro Chamber of Commerce, says of Greensboro that it is today, "the natural traveling center for 1,500 salesmen and agents because of accessibility over good roads. This and other factors have created a demand for homes and other facilities costing more than $25,000,000 as represented by the volume of building permits in the last six years. Good roads have widened our retail-trade territory to an irregular area extending from 15 to 50 miles and has put more than half a million people within one hour of the city."

All this increased consumer demand has, of course, been beneficial to rails, manufacturers, and wholesalers and retailers alike. We have, however, developed new methods of distribtuion, particularly in the short haul.

In the eastern part of the state a distributing company operates an extensive motor-truck service in putting its staple and perishable groceries in the retail markets.

At Charlotte, N. C., a chain-stores company distributes daily from its warehouses to its retail stores in North Carolina and South Carolina. It is said that the equivalent of 6 or 7 carloads of groceries is delivered in this manner under contract with a motor-truck operating concern.

Motor Vehicle Registration

The registration of passenger automobiles was 127,405 in 1920 and is today 338,192, an increase of 265 per cent over 1920.

The state has registered now 33,161 trucks against 13,455 in 1920, an increase over that year of 247 per cent.

On July 1, this year, these vehicles had paid registration fees for the last fiscal year amounting to $8,630,754 and $6,898,548; in gasoline taxes, a total of $15,529,302 for the fiscal year ended June 30, 1926.

The highway system of the state was built primarily to meet the demand of the passenger vehicles for a better roadbed over which to operate. With the improvement of the roads, however, there has developed an economic dollars-and-cents return in commercial motor transportation. To the individual passenger-car operator there is a return of lower operating expenses, shorter time involved in trips, etc.

Potatoes and sweet potatoes are handled by boat and highway to the rail connection and thence to market by the rail line from the eastern part of the state.

Imports totaling nearly $14,000,000 came through the port of Wilmington last year, and were distributed to Carolina markets by rail and motor.

From 4 to 5 tons of fish are hauled

daily by motor truck from Morehead City and other ports to points as far inland as 200 miles. Here the movement was formerly by express so that the highway has replaced the rail in distribution of fish from this point.

At New Bern, a packet company brings in sugar which requires the services of several trucks daily to distribute throughout the state.

Relation of Highways to Railroads

The year-round resorts of North Carolina have attracted a tremendous number of tourist visitors from all parts of the country. Pinehurst has almost an entirely rail movement of visitors. Golf, tennis, horseback riding, motoring, and particularly our mountain air are just as much salable commodities as our cotton and tobacco.

Hotels have sprung up rapidly in all our cities and resort centers to care for these visitors and the farmers in the surrounding country are turning to truck produce to feed them.

Some local train service has been reduced, yet in a survey of passengers carried by bus over a seven-day period, parallel to a rail line with excellent through service over a distance of 90 miles, the corporation commission found that the buses carried only 234 through passengers out of a total 6,115 handled between terminals in that period.

Many of or rail connections have been circuitous and the automobile and bus were substituted immediately the highways permitted. For example, from Charlotte to Asheville (two of the largest cities in the state) is a distance of 120 miles by an improved road completed in 1923. To reach Asheville by railroad from Charlotte one must go through the states of Georgia and North Carolina via Spartanburg, S. C., a distance of 240 miles.

Williamston and Windsor are two towns of 1,800 and 1,200 population, respectively. They are 12 miles apart and separated by the Roanoke River. Prior to the completion of a bridge and improvement of the road between them in 1922, it required 24 hours to go from one town to the other. Now, the trip is usually made in as many minutes.

Unquestionably the passenger car and improved highways have greatly stimulated the traveling habit. Many people who formerly traveled by local train now have their own cars. Many who have tasted travel in their own cars try the longer distances by rail. Unquestionably most of the rail loss of passenger business has been in local business which has gone to the private automobile. We may well give attention to the question of substituting the bus for the local passenger train. In many cases this would relieve such lines of undue burdens in providing service for the small percentage of such business remaining.

Two other cities, Moorehead City and Beaufort, are just 2½ miles apart—separated by an arm of Bogue Sound, yet the shortest highway connection is 45 miles. A rail line now connects the two, but the upkeep of the trestles which must be replaced very freqently because of destruction by the sea-water pests is understood to cost more than the revenue derived from the operation. A highway bridge three-fifths of a mile long, with highway connections is now being extended from Moorehead City to Beaufort. Undoubtedly all freight and passengers could here more economically be transferred to the highway.

Comparative figures for 1922 and 1925 are available from the state corporation commission records on some phases of the rail freight business handled within the state.

Comparative figures for three important trunk lines—the Atlantic Coast Line, Southern, and Norfolk & Western—for the years 1922 and 1925 show the tonnage originated on those lines within the state. Unfortunately the information is not available in a comparative way for years prior to the highway improvement begun in 1921. If it were, it is certain the increase in tonnage originated would be even more striking.

TONNAGE ORIGINATED WITHIN THE STATE

Carload of—	1922	1925
	Tons	*Tons*
Products of agriculture	543,680	603,388
Animals and products	32,035	46,640
Products of mines	501,411	698,788
Products of forests	1,683,072	1,750,710
Manufactures and miscellaneous	1,251,534	1,476,724
Total carload	4,011,732	4,576,250
Less than carload	686,145	683,406
Grand total	4,697,877	5,259,656

As will be noted the 1925 carload figures show an increase of 564,518 tons over 1922, or 14 per cent increase in carload tonnage originated in the state.

The less-than-carload situation showed a loss of less-than-carload tonnage originated by the Atlantic Coast Line, but an increase for both the Southern and Norfolk & Western, the total not quite offset,

however, by the loss sustained by the Atlantic Coast Line.

Beginning with 1921 our program of highway construction involved extensive rail hauling of cement, sand, and gravel. Also a tremendous tonnage of automobiles has been handled by these rail lines not alone in North Carolina but in the entire South.

Here again it is unfortunate that the figures can not be obtained for years prior to 1921, but as they stand they are illuminating as to the increased rail tonnage from these sources. The same three railroads are used; figures are given in tons of 2,000 pounds and do not include cement tonnage.

	Tonnage originated within the State		Received from connecting carriers	
	1922	1925	1922	1925
	Tons	*Tons*	*Tons*	*Tons*
Stone, gravel, and sand	451,208	667,140	1,129,147	1,466,826
Automobiles and auto trucks	1,065	16,992	42,307	100,736

The tonnage of stone, sand, and gravel originated within the state showed an increase in 1925 over 1922 of 215,932 tons or nearly 48 per cent whereas the tonnage received from connecting carriers increased nearly 30 per cent.

Tonnage of motor vehicles originated in the state is rather insignificant because so few vehicles are made there. The tonnage received from connecting carriers, however, increased 138 per cent. In both instances, although the percentage of increase is important the volume of this kind of business is the more significant item.

Movement of all kinds of freight within the state, both intrastate and interstate, is given below. The figures for only three roads were comparable for the years 1922 and 1925. Here again it is not possible to determine the percentage moving from outside points into North Carolina and from points in North Carolina to interstate destinations. The figures are in tons and are given for the Atlantic Coast Line, the Southern, and the Carolina, Clinchfield & Ohio.

	1922	1925
	Tons	*Tons*
Carload freight	20,657,105	24,861,828
Less-than carload freight	1,635,168	1,763,373
	22,292,273	26,625,201

They cover all freight handled by these lines in the state of North Carolina, whether originating on these lines, part of interstate shipments from and to North Carolina points, or simply a transstate movement.

Electric and Short Line Railroads

Just as the state reached a point of progress which attracted capital to project electric interurban lines the automobile came into prominence followed by the demand for road improvement. As a result these projects did not go beyond paper or in some instances the surveying. As a result we are today not faced with the problems in this respect that many states are.

Many of the branch steam lines and short-line steam railroads have served their purpose. People seem to prefer travel on the highway in their own cars and using their own trucks. It is time we recognized this and educated public opinion to the economic waste in forcing these lines to continue operations at a loss when the same public after voting to force continued operations, refuses to patronize the roads. The public must choose which type of transportation it wants and if the choice favors the highway there must be a closer co-ordination of rail and highway service.

One illustration is to the point. It so happens that the writer was engaged in 1909 in building 12 miles of branch-line railroad from Carthage to Pinehurst to connect with a main line at this latter point. There was a buggy factory at Carthage as well as two or three other factories, then served by a branch line 10 miles long from one of the large trunk-line railroads.

The second line was built to compete with the first for the output of the town's factories and for the hauling to it of coal, raw material and supplies, which service incidentally afforded the town relief from high rates prevailing on the other branch line.

The town was thus situated in a general way at the apex of a triangle composed of these branch lines on two sides and the main lines on the third. Neither of these branches made much money serving as feeders to the main line and as time went on handled less and less business. The interests which had in 1911 bought the branch from Pinehurst to Carthage tore up the tracks about 1914. In his connection with the state highway commission 10 years later, the writer took part in building a state highway on the grade of the branch rail line he had built in 1909.

Today the products of the buggy factory move by highway either from Carthage to the rail station at Pinehurst or over another state highway by truck to Sanford. The remaining branch line into Carthage was sold some time ago to a group of local people who wished its operations continued, but its business has declined almost to the vanishing point and it is probably only a question of time until it will be abandoned. Its business is largely in the moving of heavy, bulk freight such as coal, sand, and gravel.

Our problem in the highway field when and where called on to provide adequate highways to replace these branch lines will be the finding of means to move these heavy commodities longer distances over the highways. Other tonnage of many of these lines has either gone or is going more and more rapidly to the highways because of the generally short distances involved and the small aggregate total of such tonnage.

The data furnished might be multiplied ad infinitum but these illustrations will doubtless serve to indicate the important transportation service now rendered the state by our highway system. It serves the other transportation agencies equally as well as it serves industry, agriculture and other groups.

New fields of industry and agriculture are being opened, and the old fields are being stimulated immeasurably by the highway. It goes without saying that all this assures to the rail carriers much business from the South and proportionate prosperity.

A 148,000 YD. SUBSTRUCTURE EXCAVATION

By Frank W. Skinner, Consulting Engineer, 20 Vesey Street, New York, N. Y.

Although few Municipal buildings require the amount or depth of excavation that is here described for the New York Life Insurance Building, the well planned and executed methods and the large amount of standard eqipment that were very successfully used there are applicable to many large and difficult excavations for substructures and other requirements of important public works, especially where the quantities and dimensions are great and local conditions more or less exacting. The features of this work may therefore be suitable for adoption, suggestion, or modification for various types of work where the extent, conditions and requirements justify special consideration of safety, expedition, concentration, and the utilization of easily available high class power equipment with a small maintenance and depreciation charge and nearly 100 per cent salvage credit which was practically the case in this big New York job.

The construction of a very tall building with four stories below street level on the site of the famous old Madison Square Garden, which occupies an entire block in the heart of the city, involved a 200x425-ft. excavation with a minimum depth of 44 feet and for a considerable area a maximum depth of 72 ft. below street level. As time was of the essence of the contract three 1-yd. Thew steam shovels were installed, one of them commencing work long before the whole of the old building was demolished. Thousands of yards of masonry and concrete foundation and other debris and about 33,000 yds. of earth and 125,000 yds. of hard gneiss rock were removed in successive lifts 10 to 16 ft. deep, and the steam shovels, moving back and forth transversely, delivered to a fleet of more than 55 automobile trucks, most of them Macks, that hauled the spoil a mile or two over different routes arranged to avoid congested traffic or interference with each other, and terminated at eleven piers on opposite sides of Manhattan Island, where it was deposited in the hoppers of sea-going dump scows except about 18,000 yds. of rock that were sold to local users for foundations, walls and the like.

As soon as possible the steam shovel loading was supplemented by the installation at equidistant points around the site of the lot, of eight derricks having 70 and 80-ft. booms each equipped with a 2-drum Lidgerwood Hoisting Engine and Swinger. These commanded all but a small portion of the center part of the lot and handled more than 50 2-yd. scale pans which with their contents at an average weight of about 7,000 lbs. on a single line were hoisted 40 to 80 ft. at a speed of 325 ft. per minute and delivered to trucks at street level. The effort of the George J. Atwell Company, Inc., Contractor for the excavation, was to remove all of the stone as fast as it could be shattered and a group of six or eight scale pans in the area commanded by each derrick enabled them to be successively filled at the point where the material was thrown by the blasts without rehandling or causing any delay by waiting for an empty scale pan while a full one was being hoisted, dumped and

returned. The result was that as many as 14,000 yds. of rock were removed from the pit in a single 8-hour shift. Mr. George S. Kelly, master mechanic, wrote, "We have eight Lidgerwood rigs now in operation working as hard as a hoist can be worked on this job. The majority of the hoists are 80 ft., averaging 3½ tons. My highest day's work for one rig has been 70 (truck) loads, three hoists to the load, in 7½ hours."

The rock was drilled at the rate of about 90 linear ft. per day by 43 jackhammer drills that together used daily about 6 tons of steel requiring six men and two machines to keep them sharpened. Compressed air was furnished by two electrically driven compressors with a combined capacity of about 2,500 cu. ft. per minute and was delivered to the pit through more than 1,200 ft. of large mains encircling the pit at street level, that themselves acted as a supplementary reservoir and were connected with numerous vertical drop branches supplying the hose connections to the drills.

The holes were charged with 40 per cent dynamite and were carefully covered with double layers of 12x12 and 14x14-ft. wire rope mats that smothered the explosions and prevented the fragments of rock from flying out of the pit.

The trucks that served the steam shovels entered and left the pit on steep ramps that were carried down to a maximum depth of 44 ft., one shovel loading as many as 61 trucks in an 8-hour shift. In a 100x200-ft. portion of the pit which was 72 ft. deep, the rock was removed entirely by the derricks, two of which were seated on cantilever supports beyound the face of the excavation; the remainder were supported on timber towers on the tops of rock pilasters temporarily left intact. The large amount of water flowing into the pit was drained to two sumps from which it was removed by one 4-inch electrically-driven turbine pump and two gasoline-driven 3-in. piston pumps. The electrically-driven hoisting engine was equipped with improved standard type extra wide brake bands, insuring extra rapid and positive control. The equipment on the job was under the constant supervision of the master mechanic and required practically no repairs or renewals. The steam shovels, which of course had severe service, handled about 18,000 yds. of rock in 91 working days at a cost of about 0.8 cts. per cu. yd. for renewals, mostly of minor parts. The shovels were mounted on caterpillar tractors, and consumed for each 8-hour shift 1¼ tons of coke, one gallon lubricating oil, and 2½ lbs. of grease.

The earth sides of the pit above the rock surface were retained by about 1,200 lin. ft. of gravity section wall 18 ft. in average height, the lower portion of which contained about 1,000 yds. of concrete made in a T. L. Smith portable mixer and securely doweled to the solid rock. This construction, although apparently more expensive than ordinary temporary work, in reality costs less than temporary braced steel sheet piling, and had the double advantage of permanent service for vault walls and the like and the elimination of all obstructions from inclined braces which would otherwise have impeded excavation operations. The approximate cost of the general excavation, exclusive of shallow pits for column piers, was about $1,000,000.

The maximum force employed was 325 men, working single shifts, under the direction of M. S. McKenna, superintendent. Cass Gilbert is the architect of the building, and Starrett Brothers is the general contractor.

HYDRATED LIME AS FILLER IN ASPHALT MIXTURES

Hydrated lime as a filler in asphalt mixtures produces higher stability values than equivalent amounts of the more commonly used materials, investigations conducted over the last three years by Prevost Hubbard and F. C. Field, of the Asphalt Association, disclose. These investigations were instituted because a greater resistance to displacement is necessary in order that bituminous mixtures may successfully resist the stresses to which they are subjected by modern traffic.

The investigators went thoroughly into their work covering the entire field. They developed a highly satisfactory method of testing for stability asphalt briquettes, which might either be cored from pavements or prepared in the laboratory. Supplementary to their report they made the following statement:

"Recent investigations of methods of increasing and more closely controlling resistance to displacement of asphalt pavements under modern traffic have emphasized the very important stabilizing effect produced by mineral fillers as a constituent of paving mixtures.

"It has long been realized among paving engineers that fineness is a neces-

sary characteristic of good fillers, but the effect of variations in fineness has never been thoroughly understood. Moreover, only a very limited number of types of finely divided substances have been used so far in paving practice.

"Among the little used products which are widely available in large quantities, hydrated lime gives promise of being particularly well adapted for use as a filler both on account of its extreme fineness and surface texture.

"It is believed that the research data secured relative to this material, coupled with practical results obtained where it has been used in actual construction, merits its favorable consideration by paving engineers in future work."

Summarized, the conclusions reached by the investigators based on their previous work and that presented in a bulletin by the National Lime Association, entitled "The Value of Hydrated Lime as a Filler in Asphalt Paving Mixtures," are:

1. Hydrated lime is a more efficient stabilizing agent in asphalt paving mixtures than is the average limestone dust filler when used in the customary percentage of the total mix.

2. No difference in the stabilizing value of different limes can be attributed to differences in chemical composition, i. e., whether the lime is high calcium or high magnesium.

3. The maximum stabilizing and void reducing effect of hydrated lime in paving mixtures containing a well graded sand appear to be obtained by the use of approximately 15 per cent of lime.

4. In sheet asphalt paving mixtures with well graded sand it appears that about 13 per cent by weight of hydrated lime is equivalent to 20 per cent by weight of average limestone dust, and about 8 per cent of lime is equivalent to 15 per cent of limestone dust.

5. Hydrated lime appears to be better adapted for use with a relatively soft asphalt cement than is limestone dust, and when so used indications point to the production of mixtures of high stability at 140°F. which are less likely to crack in cold weather.

6. Hydrated lime is an especially desirable filler for use with uniformly fine sand and its superiority to limestone dust for such use may make available for sheet asphalt construction fine sands which are at present eliminated by specifications.

HIGHWAY RESEARCH IN MICHIGAN

By V. R. Burton, Engineer, Michigan State Highway Department, Lansing, Mich.

The major project of research at present under way in Michigan is a study of the various designs of pavement and pavement drainage used in the past, taking into account the character of the soils in which they are laid. It was the thought of the Department heads that the work done previously should constitute a great outdoors laboratory which should show much more truly the performance of different designs under various conditions than could any setup of the more or less artificial conditions necessary to an experimental road. The collection and classification of this information is being handled through the agency of a pavement survey and soil survey at present in progress.

Certain facts have been determined already. A study of a number of "sink holes" in peat marshes has radically changed the policy followed in handling situations of this kind. It was the former practice to load these peat marshes as lightly as possible to avoid settlement. The study made demonstrated the fact that settlement is bound to occur anyway, and the logical policy to follow is to encourage rapid settlement by heavy loading so that the fill may be stable when surfacing is placed. New methods of placing these fills have been worked out which insure material savings in earthwork besides producing a stable enbankment.

The curing of cement concrete pavements by the surface application of calcium chloride has been investigated in both field and laboratory. The results obtained have led to the abandonment of the use of this method of curing due to its tendency to accelerate surface scaling. The use of this chemical as an integral admixture is at present being investigated. Standard test cylinders and beams are being made on a paving job and the strength increases over various curing periods and at various temperatures noted. The effect on the surface of this method of curing will also be investigated, as this effect is considered fully as important as the beam strength of the concrete.

A preliminary study of under-drainage has shown that tile under-drain, either with or without gravel sub-base, when installed at a good depth along the edge of the pavement slab, is very effective.

On one project built two years ago on one of our heaviest traveled roads, stretches of pavement are in perfect shape with no other cracks than the 100-ft. joints for as long as a half mile at a time. This sub-grade is heavy clay treated with gravel and sand sub-base and edge tile, and was considered so difficult by the county highway authorities that it was claimed no rigid pavement could be built on it. Sub-base, unless thoroughly drained with tile, has been demonstrated to be worse by far than no sub-grade treatment at all.

The cause of frost heaves in pavement has been investigated and, for those investigated at least, has been shown to be due to radical changes in soil texture. This work will be carried on through the coming winter and the effect of measures to prevent this heaving which have been installed during the past summer observed.

Very interesting experiments with snow fence have been planned for this coming winter. It is planned to investigate the effectiveness of various types of snow fence for standard heights, the effect of height of fence on the length of drift formed and also the proper spacing of pickets for the picket type and boards for the board type. A complete meteorological station has been erected to give data on drifting conditions as influenced by wind velocities, temperature, humidity and sunshine. The amount of snow reduction due to temperature and sunshine will also be studied.

No data of any kind on this subject are available so far as is known, and for Michigan this subject is an important one. It is confidently believed that a liberal and intelligent use of snow fence will permit of the substitution of light, fast-moving equipment for the heavy tractor plows now necessary. This will not only give cheaper costs but a service which is incomparably superior.

A number of research projects are being carried on at the State Highway Department Laboratory. The effect of non-standard cement on concrete, the relation of the results of the 7-day mortar tensile test to the 28-day—if any, the effect of the height of mixing table on the strength of mortar briquettes, the effect of cross-section variations in the tensile strength of mortar briquettes, etc., are all being gone into.

Last winter the effect of the use of calcium chloride for surface curing on the surface of concrete was thoroughly investigated by the laboratory. The results of this investigation checked the field studies previously referred to and as a consequence the use of the material in this manner was discontinued.

A laboratory study of the expansibility on freezing of soil separates with varying water contents has just been started, and will be carried on through the winter. Considerable information of interest to those engaged in sub-soil study should result from this work. It is very little understood by engineers in general that a considerable portion of the water held in certain soils will not freeze even under very low temperatures and that actual water content is no measure of the expansibility to be expected.

The research work on soils will necessarily take a considerable period of investigation before results will be at all complete. It is highly probable that this work will extend over several years bebore complete classification can be effected. About 500 miles of pavement were covered this summer and the data will be worked up during the winter. Considerable preliminary information should be available by the spring of 1927.

CONVENTION AND ROAD SHOW OF AMERICAN ROAD BUILDERS' ASSOCIATION

Plans have been completed for the Annual Convention and Road Show of the American Road Builders' Association which will be held in Chicago, January 10th to 14th, 1927, during Good Roads Week.

The Convention will be attended by highway representatives from every State in the Union and from several foreign countries. Mr. H. K. Bishop, of the Bureau of Public Roads is General Chairman of the Program Committee and he has been assisted by Mr. Paul Tebbs, Construction Engineer of the Pennsylvania State Highway Commission, as Chairman of the Engineering Section, and Mr. Sam Williams, vice-president of the Autocar Company, as Chairman of the Construction Section. Special attention has been given this year to select topics that are especially important and of great interest to the highway industry.

Those appearing on the program are men that have been selected because of the attention they have attracted in the activities of their State.

The first day of the Convention will

be "Governors' Day." Invitations have been sent to Governors of all the States and to a few former Governors who were especially active in sponsoring a highway program. Already sufficient acceptances have been secured to assure the day being a huge success.

During the afternoon of Governors' Day there will be a special trip planned for the Governors to attend the Road Show in a body. Upon returning to headquarters the attending Governors will be the guests of President Shirley and the Directors of the American Road Builders' Association at the Governors' Day banquet. Mr. Fred Reimer is Chairman of Governors' Day and will have charge of all activities.

Wednesday, January 12, 1927, will be known as Pan-American Day, and one-half of the day's program will be given over to papers presented by Engineers from countries of the Western Hemisphere outside the United States.

Col. R. Keith Compton is Chairman of this day and the Pan-American program will be jointly presided over by him and Mr. Francisco Diaz Leal, member of the Federal Highway Commission of Mexico. There will be provision for the delegates of all foreign countries to visit the Road Show. It is possible that a trip to the Road Show will be arranged after the Road Builders' banquet when the hall will be clear of the crowds.

The delegates of the foreign countries will be the guests of President Shirley and the Directors at the Road Builders' banquet, which will be held at 7 p. m. in the Grand Ball Room of the Palmer House on Pan-American Day. It is expected that 2,000 people will attend the banquet. Arrangements with a speaker of National reputation are now being made.

Thursday is set aside especially for State Engineers and officials to visit the Road Show, and especially the several State exhibits which will be held. Among the States that have already planned to send exhibits are Florida, Missouri, Nevada, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennesse, Virginia, West Virginia, with several others now making plans to be present. In addition to this exhibit there will be exhibits for Alaska, Canada, Mexico, Argentina, Cuba, Chile, Peru, and from our own Bureau of Public Roads.

Booths will also be occupied by the American Association of State Highway Officials as well as the Highway Research Board, and the Department of Commerce.

Dr. F. A. Hathaway, Chairman of the Florida Highway Commission, is Chairman of this day and will have charge of the various events in connection with States' Day. This new day is bound to prove of interest, not only to engineers and officials, but to all in attendance. Several States have reported that special trains will be run to the Road Show and it is expected that before the time arrives for the Road Show to open its doors many more special trains or cars will be arranged for.

Reduced rates have been granted by all railroads. When buying your tickets to Chicago, secure the certificate from the ticket agent. This will be validated at the Coliseum and permit you to purchase the return fare at one-half price.

The Road Show, the greatest Exposition of the latest improved road machinery ever held, will have a spectacular opening at 8 p. m., Monday, January 10, 1927, and remain open till Friday, January 14, 1927. The exhibits will be arranged at that time and something new will mark the opening.

The Coliseum Committee will be headed by Mr. John E. Tate of the Portland Cement Association, who will have charge of placing the exhibits and other details.

The Registration Committee is headed by William Ogden of the Lakewood Engineering Company. He will have charge of registering all those attending the Road Show and distributing the registration lists.

Already over 300 carloads of machinery and materials have been arranged for display at the Road Show. Manufacturers have arranged to bring out their latest improvements at this time. More manufacturers have applied for space this year than ever before, which made the allocation of space even more difficult. Recently, the Wilson Building, a building adjacent to the Coliseum, has been secured, which means additional space for those wishing to bring out new developments and making the 1927 Show the largest ever held.

The Exposition will be a true cross section of the Highway Industry, and those interested in any of the branches of construction, maintenance or operation will find the latest development and improvements on display.

The exhibit of the United States Bureau of Public Roads at the Coliseum will depict all conditions in the road field

and finally finish with the exhibit of the highway commission of Utopia. The Bureau's exhibit will carry the same educational features but as an addition it will project the conditions into the future and show us what we may expect.

The hotel situation in Chicago has been greatly improved during the past year but the increased attendance that is expected will mean that you should make your reservation early. Use the American Road Builders' Association "Hotel Booklet." Write direct to hotel or to Mr. William J. Hennessy, 10 South LaSalle Street, Chicago, who is in charge of the hotel committee.

The headquarters of the American Road Builders' Association will be at the New Palmer House and the offices will be opened after December 5, 1925.

Good Roads Week will not only be observed by the Convention and Road Show of the American Road Builders' Association, which will be held in Chicago, January 10 to 14, 1927, but civic clubs throughout the United States have been asked to include in their programs road matters of local interest and schools have been asked to take note of this week by having a short program of general interest in road matters, setting forth the advantages and benefits of good roads and the part they play in the progress of the nation.

The second annual college essay contest, conducted by the American Road Builders' Association, will close during Good Roads Week, and the prize winners will be selected by a committee, and the announcement made at the Road Builders' banquet. The announcement of the prize winners will also be made by radio and the speech of the principal speaker will also be broadcasted.

CITY TYPE PAVEMENT ON RURAL HIGHWAYS

By Henry Brevoort Smith, County Engineer, Burlington County, Mt. Holly, N. J.

(Paper read before the Fifth Annual Asphalt Paving Conference, Washington, D. C., Nov. 8-12, 1926.)

Many thousand miles of bituminous pavements throughout the rural districts of the country attest to the fact that engineers are awakening to the possibility of using city type pavement on country roads. The splendid results obtained by this type of construction, as well as its great economy, is bringing it rapidly to the front. One of the outstanding characteristics of bituminous construction is its remarkable flexibility—a flexibility that allows many interesting types of both design and actual construction.

One of the principal problems that confronts the rural districts today is adequate highways with a minimum cost. Not only minimum cost of construction, but minimum maintenance. It is absolutely essential to the growth and development of a community that it have modern transportation facilities, and this means improved roads. A rural, or sparsely settled section of the country, is dependent upon its highways, and these highways must function the entire year. The country is rapidly awakening to this need, but the question of the type and cost of construction calls for intensive thought.

There are many types of bituminous pavements that fill this need, but the city pavement type is principally confined to Penetration Macadam, Sheet Asphalt, Topeka and Bitulithic. These four can be again sub-divided to some extent, but as my talk will be principally confined to sheet asphalt construction, I will not go into the relative merits of the various types.

And now let us turn our attention to Burlington County, a rural county in southern New Jersey, that has constructed over eighty-five miles of sheet asphalt highways through the county in the last few years, besides a considerable mileage of penetration macadam. About nine years ago, Burlington County realized the need of immediately improving its highway system, as its old macadam roads were being rapidly destroyed by the ever increasing vehicular traffic, and the cost of maintenance was amounting to a prohibitive figure. Many types of highways were studied, but most of them involved the destruction and wasting of the old macadam roads, which was not thought expedient. After discarding first one kind of pavement and then another, the field narrowed itself down to a type of pavement that could be laid upon the old stone road, using it in some way as a base. Finally the use of sheet asphalt suggested itself, and an intensive study was made of the characteristics of this type of pavement. Again came the questions, was it suited to country roads, how long would it last, what was its cost, and would it be expensive to maintain? These questions were threshed out pro and con, and at last it was decided to try it out on an experimental base.

Having decided on a sheet asphalt

pavement, the next question was how to salvage the base and properly utilize the stone, or road metal. Most of the macadam roads varied in width from 10 to 12 ft. and had much too high a crown for a bituminous pavement. They were also variable in depth, and some even had an old telford center. It was decided that the first county pavement to be constructed should be 18 ft. wide and this included the widening of the existing stone road to conform with the new pavement width. This was done by forming a trench 6 ins. deep and approximately 4 to 5 ft. wide, on either side of the old existing stone road, and filling it with 2½ ins. of broken stone. This stone was then filled with a local gravel binder and thoroughly rolled until compacted. After this was done, the center portion of the road was thoroughly scarified and the excess material in the crown, evenly distributed over the entire width. New stone was added where necessary to correct any fault in the contour or to reinforce the base where necessary. The whole was then thoroughly covered with screenings, waterbound and rolled. This base was then subjected to traffic for a period of approximately 30 days, so that any weak portions would develop before the pavement was laid.

Following this came the construction of the sheet asphalt pavement composed of 1½ ins. of binder and 1½ ins. of surface mixture, making a total pavement of 3 ins. This thickness has been varied from time to time in the hope of making some real improvement and for a while a 2 in. base course and a 1 in. surface promised to give excellent results, but during cold or chilly weather it was more difficult to prevent honeycombing so we have gone back to the original thickness of 1½ ins. of binder and 1½ ins. of top.

Before commencing the actual laying of the pavement the stone base was thoroughly swept with a rotary broom and all excess dirt and screenings removed; 3x6 in. wooden forms are then laid to line and grade on the extremities of the base and are securely held in position by iron pins. The 1½ in. binder course is then laid, care being taken to remove any minor depressions or hot holes that are in the base. The binder is then thoroughly rolled and whenever possible covered with surface mixture during the same day. The following day the pavement up to this point is thrown open to traffic.

Of course, many deviations from the outlined method of construction are often necessary. At times we must modify a curve, realign certain sections of the road, etc., which require an entire new stone base, a slag base or perhaps a concrete base. Drainage plays a vital part in the construction of any road and as the old saying goes, "Your road is as good as your drainage," applies to this type of highway.

Through most of our towns in Burlington County, the sheet asphalt is laid on a 6 in. concrete base, but to date it is impossible for a stranger to tell which is laid on a stone base and which is laid on a concrete one. Both type bases, when properly constructed give excellent results, but usually where we find it necessary to completely remove the old stone base in a town, so as to correct the grades, etc., we consider it advisable to put in a concrete base. We have also had splendid results from the so-called "Black Base" where it was imperative to open the street immediately for traffic, and not wait for the length of time necessary for a concrete base to set. It might be interesting to note at this point, that a great many of the smaller county bridges along our roads have been paved with sheet asphalt directly over the deck, so that the road and bridge present a uniform grade, and eliminate any jar or bump in passing over one. This statement applies to both wooden and concrete decks and in some cases to old block decks. The results along these lines have been excellent, and we are very much pleased with them.

Burlington County has a total of 242 miles of county highways under its jurisdiction, exclusive of town, city and township roads. These roads are maintained by its own county forces, who carry on all the maintenance work. During the past few years this maintenance force has both grown and developed, and now much of our stone base construction as well as penetration macadam roads are built by them. As yet we have carried on no sheet asphalt construction with these forces, but some day in the near future it may be advisable for the county to install a small patching plant to care for our many miles of improved roads.

Naturally, after having built the type of pavement we have for nine years, and studied our traffic problems we have a comprehensive road program laid out. At this time it is our policy to build all roads not less than 20 ft. in width, a 21 ft. stone base and adequate shoulders. Secondary traffic roads are carefully constructed of penetration macadam, the same width as our sheet asphalt roads, so as the county develops they can be

easily surfaced with sheet asphalt without any more reconstruction of the base. This, as you can readily see, is an economical program, and allows us to utilize and conserve both material and money and at the same time is giving the entire county and the traveling public a splendid highway system. At present we are constructing new roads at the rate of ten to twelve miles a year. Of course, this figure varies considerably but it is our general average.

Our costs for the various roads are interesting and we feel we are getting a dollar's worth of road for every dollar of the county's money expended. In round figures, our penetration macadam roads 20 ft. in width, including reconstruction of the base, shoulders, etc., run between $16,000 and $18,000 per mile. Our sheet asphalt highways 20 ft. wide, including reconstrction of the base, shoulders, etc., average approximafely $27,000 to $30,000 per mile. Each individual road, of course, varies considerably, but usually it takes about 2,000 to 3,000 tons of stone per mile of macadam base reconstruction at $5 per ton in place including all the incidental work. This latter figure, of course, applies only to sheet asphalt construction. The prices on sheet asphalt also vary widely, depending on the location of the roads, railroad facilities, haul, etc. However, our average cost per square yard is approximately $1.40 for a 3-in. sheet asphalt pavement. At this point it might be interesting to note that the county's specifications require a weight of 170 lbs. per sq. yd. for 1½ ins. of surface mixture, making a total of 320 lbs. for the finished pavement. The weight is slightly above the average required for most 3-in. sheet asphalt pavement, but it gives a little latitude in filling minor depressions or slight pot-holes in the macadam base, without weakening the rest of the pavement.

Our oldest pavement is now going into its tenth year and our maintenance cost on it has been nothing. This road carries heavy traffic, and during the war was one of the main arteries to Camp Dix and was subjected to heavy motor truck train travel. Some of our sheet asphalt roads have needed minor maintenance on them, but the average is less than $50 per mile per year to date, which we consider a remarkable tribute to this type of construction. Of course, in many of the towns openings in the pavement have been made for gas, water and sewer, but these are easily repaired with a temporary mixture of asphalt cold patch, and later after settlement has taken place, with a hot mixture. A charge is made by the county of $10 per sq. yd. for the road openings in its pavements, and this sum is more than ample to properly repair all cuts. Usually it is advisable to wait until quite a few openings have been made before having a hot patch gang go out, and it has been our practice to do this class of work twice a year, namely, in the spring and late fall.

After nine years of bituminous construction and with 85 miles of sheet asphalt pavement, and many miles of penetration macadam, we are satisfied that our judgment in selecting city type pavements for county highways has been vindicated, and that they are not only cheaper per mile as to first cost, but materially lower in maintenance.

EXPERIENCE WITH VARIOUS TYPES OF PAVING IN CALIFORNIA

By C. S. Pope, Chief Construction Engineer, California Highway Commission, Sacramento, Calif.

(Paper read at 1926 meeting of League of California Municipalities.)

The experience of the California Highway Commission with paving of various types dates from the year 1912 when Contract Number One was awarded for the paving between South San Francisco and Burlingame. This pavement consisted of a 5-in., 1-3-6 concrete base and a 1-in. sheet asphalt surface. It was 24 ft. in width and the construction was of such satisfactory character that it endured traffic without serious distress until the year 1925 when it was widened to accommodate increased traffic, repaired and resurfaced in part.

The third contract let by the Commission in 1912 was the bituminous macadam surface extending from Madera to Califa. This macadam is 15 ft. in width and was constructed in 1912 and 1913 and it is still in fair condition.

While the analysis of conditions to be met was not as thorough in the early years of the Commission as is the present custom, it must be remembered in judging the work of past Commissions and engineers that there has been an enormous increase in the information available to highway engineers within the last 10 years and a very notable advance in the education of the public in matters of highway construction.

The large expenditures of the present

day for highway construction which are accepted as necessary by an educated public would have been the source of a storm of protests in the early days of the Commission. While many think that the first Commission stretched their money too far on the construction of light highways, none of us are in a position to know as well as these former Commissions and engineers, the pressure which was brought to bear from all sides demanding the completion of highways in the different parts of the State.

I think it behooves us all, therefore, to look with a sympathetic eye on the work formerly done and to devote ourselves more particularly to seeing that our own work is of such character that future critics will have little ground on which to base adverse comments of the work done in this day.

From the construction point of view, the work previous to 1924 differed from that being done at the present time, principally through the lack of co-ordination, of methods in the supervision of the materials used in construction and also of the operations of construction.

The successes attained on the many satisfactory highways built previous to 1924 was due in large measure to an efficient division engineer coupled with a resident engineer who understood good construction and saw that work was properly done.

At the present time, the system is entirely different, and division engineers are given much more assistance than in the past. All features of construction and the construction materials are well analyzed before a contract is let. When construction actually begins, there is advisory supervision so that the work in all parts of the State is done with equally satisfactory results and with uniformity of methods which was not possible before.

Figures are difficult to remember and are of little value in such a talk as this but in order to indicate roughly the classes of work which have been done by this State, I will give you some approximate figures which are reasonably correct up to June, 1926.

The aggregate length of the State Highways is about 6,500 miles, of which about 4,100 miles have been improved by paving or otherwise and of which some 2,400 miles have not yet been built. You will realize from this statement the urgent necessity which lies before the people who wish to see this highway system completed to provide the means necessary for the purpose.

Of the paved roads, the division of mileage is about as follows:

Asphalt Macadam	about 330 miles
Portland Cement Conc.	about 1,650 miles
Asphalt Concrete on Macadam	about 90 miles
Asphalt Concrete on Concrete	about 270 miles

The construction of highway paving should really be thought of along two separate lines. The first is the construction of an original highway on new grade and the second is strengthening and widening of the highway already constructed. In the first case it is necessary to make a close examination of the soil and all other conditions which might affect adversely the pavement. In 9 cases out of 10 we find it desirable to do the grading first and then construct a surface of gravel or crushed rock to carry traffic for a number of years until we are assured that the stability of foundation has been secured. In mountain work, it is of course essential that all fills should be thoroughly settled before any attempt at paving is made and those of you who live in Northern California or the mountainous country of the south also will naturally realize the length of time which must elapse before certain sections of the mountain roads can safely be paved.

On reconstruction or strengthening and widening work it is necessary also to examine the soil but more particularly to examine the condition of the pavement which remains in order that the most economical type of resurfacing may be secured.

In connection with the design of many types of paving, we have found the most desirable and necessary requirement to be that we should know the traffic which this pavement will be called upon to sustain. In order to secure this information, the State has established a great number of traffic census stations in various parts of the State and from these we are able to determine with very considerable accuracy, not only the traffic which a road has borne, but that which it will be required to carry in years to come. With this information at hand, it is possible to make an economical study of the proper pavement to be used in a given location.

The great success which the Highway Commission has recently had in the improved constructions of its pavements is due to a number of causes.

The first of these is the fact that the Highway Commission has left the highway work and its technical phases entirely in charge of the State Highway Engineer.

The second is that the present State Highway Engineer is not only a man of wide experience himself in highway work and gives to its many phases his minute personal attention but also he is sympathetic with the aims of the Construction Department which was organized under his direction and gives to it his full support.

This Department comprises two functions, one of which is handled by the Testing and Research Laboratory of the Construction Department and the other by the field inspection and supervision which is given by engineers of the Department.

By means of the Testing and Research Laboratory, it is possible to make preliminary examinations of the materials proposed to be used in construction and predict with considerable accuracy the results which will be obtained. It is also possible to do a considerable amount of research and experimental work which would not be possible in a smaller organization and which is a phase of work practically never open to a small city. The Research Department can, therefore, be of great value to all the other highway departments and all interested in similar work and the problems submitted to it can be handled in such a way as to increase the quality of construction very materially.

The general supervision exercised by the Construction Department also makes it possible to secure the best methods of construction and uniformity of workmanship throughout the whole State and also enables the Department to observe the results obtained by advanced methods of construction which are tried out from time to time. The whole success of the construction work is, therefore, due to an intelligent analysis of materials and the close inspection of the construction work itself by engineers thoroughly experienced in this kind of work.

A description of some of the details used on the construction of pavements may be of interest in indicating the reasons for the successful work obtained by the Commission.

For the construction of a concrete pavement, for instance, the laboratory is requested to furnish tests of the strength of cement and the quality of sandstone and water which will enter into the work. The precise proportions of the mixture to be used are worked out by the Resident Engineer with the assistance of an engineer from the Construction Department. Usually, actual concrete specimens are made before the work starts in cases where the material is not one which has been in commercial use. The equipment used for proportioning materials, for mixing concrete and for spreading and tamping the same are carefully examined and must conform to set standards before their use will be permitted. The depth of subgrade is carefully measured just previous to laying of the concrete and the correct yardage is figured from the notes so obtained. The proportions of the materials used in the concrete are either weighed or measured by volume with a great deal of accuracy and corrections for the amount of moisture in the sand and stone are also made a number of times a day. In addition, the grading analysis for relative sizes of the different particles of sand and stone are made a number of times daily and are used in computing the voids which may be expected in the mineral aggregate.

The State Highway proportions vary from those usually specified in that we call for a certain number of sacks of cement per cubic yard of concrete in place, which eliminates all questions of how far a barrel of cement will go in our paving and other construction. The contractor has to concern himself then only with the proper proportions of sand and stone.

The amount of water used in each batch is carefully proportioned either by weight or volume and daily a sample of concrete is placed in a cylindrical mould and made into a test specimen from which a determination of the compressive strength of the concrete laid during that day is made.

All of the details of the work are covered by a complete set of report forms so that every step of the procedure is a matter of record and yet the report forms are not so intricate as to be a burden on the inspecting engineers. It will be interesting to note in this connection that at the beginning of this system in 1923 a concrete having a compressive strength at 28 days of 2,000 to 2,500 pounds per square inch was considered satisfactory. During 1924, the strength rose to about 3,500 pounds and in 1925 to about 4,200 pounds. It is probable that during 1926 the average will show very nearly 4,800 pounds, which I believe is far in excess of the strength obtained in any

other states. This increase in strength has been obtained at no increased cost either in inspection or with undue hardship to the contractors. In addition to securing concrete of uniform strength, there is in effect a system by which we secure concrete of uniform smoothness. There is attached to one or two of the automobiles belonging to the State, a machine known as the Vialog or Roughometer, by which we are able to obtain the amount of roughness per mile of paving, simply by running a machine over the highway at a uniform rate of speed. By the use of this machine it is possible to compare the care used in one job as against another or on one part of the job as against any other part. The resulting use of this apparatus has been to decrease the roughness of pavement to a great degree. Taking the 1924 pavements as a unit for comparison, the 1925 pavements contained about 2/3 the roughness of the 1924 pavements and the 1926 pavements will show about 1/3 the roughness of the 1924 pavements. Pavements in 1924 were considered fair when they showed a roughness of 15 ins. per mile where the 1926 pavements are considered poor as to smoothness if they show a roughness in excess of 5 ins. for Portland cement concrete.

Asphalt concrete has been used to a considerable extent by the State for both surface and in some locations for a complete pavement. For a number of years the development of this type of pavement stood still but during the last year we believe that a new type has been developed which will be far superior to that used in the past. In this type of pavement the amount of asphalt is greatly reduced and the amount of very fine material is greatly increased. Also, we have eliminated the old type of seal coat and are constructing the seal coat of stone chips which gives promise of excellent results and will for a time render the pavement non-skid. A sample of the new pavement completed is seen at Delano and another sample will be under construction within a few days at Modesto. This type of pavement is under the same careful supervision as is the Portland cement concrete pavement. Samples are taken daily and sent to the Laboratory for analysis and there is an inspector constantly on the plant engaged in seeing that the proper proportions and sizes of materials are used.

In connection with the plants used for the manufacture of mixing this type of pavement, we are introducing automatic recording weighing devices by which we are able to keep a permanent record of the different weights of materials going into the mixture. This is an advance in practice first specified by the Construction Department and gives promise of a wide extension to other types of paving. The Vialog is especially useful in this type of paving in checking up the work in its early stages so that the Resident Engineer will have an opportunity to improve the riding qualities of their pavements as they go along.

The most notable of the asphalt concrete pavements recently constructed by the State is that across the sand hills from Yuma west, which was completed within the last few days. This pavement is some 6½ miles long and was constructed in about 100 working days without regard to the intense summer heat or the sand storms endured by the workmen engaged in this construction.

In the bituminous macadam construction, the State pursues the policy of first building a substantial base of broken stone or cementing gravel. On this, after it has come to rest and is perfectly sound, there is laid a wearing surface of bituminous macadam varying in thickness from 1½ to 3 ins., depending on the traffic to be borne. The methods of construction are quite fully outlined in our specifications and need not be reverted to here. The resulting pavement, if carefully constructed, gives an economical and satisfactory wearing surface but the details of construction must be carefully observed or failure will result. This is probably the most difficult type of construction on which to get uniform results and is one of the least used in State work.

On new grade and in outlying sections of the State, the standard construction is the grading of the highway with proper alignment as to curves and grades and surfacing the same with crushed rock or gravel. The practice during 1925 and 1926 was to surface these roads with crushed rock ranging in size from 1 in. to dust. In the best construction this material was spread in light layers and was watered and rolled on its completion and dragged thereafter practically continuously to keep it in shape. This has made a most economical and successful high speed road in desert locations. For instance, on the road from San Bernardino to Needles, the construction of such a highway has enabled the running time to be cut from 9 to 5½ hours and there is entire freedom from any chance of

accident or from people getting stuck in the sand or having to stay on the desert during hot weather. Recently, the complaint as to the dust nuisance has made it seem desirable to oil many of these roads and this has been done with considerable success in certain parts of the State.

A summing up of the experiences of the State organization in paving is as follows:

We find it desirable first to construct a well compacted foundation of road metal, either crushed stone or gravel some 6 ins. in thickness.

After this material has come to rest, and a well bonded foundation is available for paving, a paving of bituminous macadam, asphalt concrete or portland cement concrete is placed over the metaled road. The selection of the type of paving depends, to a certain extent, on the funds available but very largely on the amount of traffic and the economical expenditure which would be desirable in the particular case.

State highways differ from city streets in that they form narrow lanes of traffic on which traffic is rather restricted and great care must be taken to keep vehicles from running in the same lanes. This type of travel is paralleled in the city where car tracks exist and where you have no doubt noted the street paving soonest shows distress. A wide road gives a better distribution of traffic throughout its surface than a narrow one and this feature also affects the type of paving to be used.

. The Construction Department is often required to answer letters from various persons or municipalities asking which ence of the State highway. All types of pavement have their use under certain conditions and without a knowledge of these conditions properly analyzed by an experienced engineer it is impossible to give an answer which can be generally applied.

On each State Highway car you will note the State Highway seal showing a winged wheel with the instruments of engineering science and of labor combined and encircling these symbols an inscription in Latin which freely translated is as follows: "Energy directed by science is the road to fortune."

Whatever success we have had can be ascribed to intelligent engineering and careful supervision and if the cities and towns of the State will spend the necessary amount of money on intelligent engineers and proper supervision, it will not be necessary for them to go outside the ordinary methods of construction to secure lasting and satisfactory streets.

SOLVING THE TRAFFIC PROBLEM AT MINIMUM EXPENSE

By W. Graham Cole, Safety Engineer, Metropolitan Life Insurance Co., New York, N. Y.

(Address before 17th Annual Meeting of Conference of Mayors and Other Municipal Officials of the State of New York.)

With the tremendous increase in the use of automobiles within the past few years, the safe and expeditious movement of traffic has become one of the most important problems confronting the authorities of American cities. Streets which were designed to accommodate vehicles drawn by faithful old Dobbin at a speed of only a few miles per hour, were suddenly forced to carry thousands of miniature locomotives capable of high speeds and controlled by the whims and fancies of individuals, many of whom a few years before hardly knew the difference between a steering wheel and a carburetor.

It is obviously impossible to redesign entirely the streets, particularly in the business portions of cities where traffic congestion is greatest and where property values are high, in order adequately to accommodate this new traffic. It is possible, however, to make some changes at present, to prepare plans for essential future changes, to consider the needs of traffic in laying out new streets and to impose certain control methods which will furnish some relief to congestion in the overcrowded streets of the modern city.

The suddenness with which the traffic problem has overtaken municipalities has of itself imposed an additional problem in the city administration—that of securing necessary funds for properly handling the situation. The individual motorist and pedestrian are quick to express themselves regarding the congestion and dangers of the streets and to condemn those in authority for the existing conditions. On the other hand, public opinion does not appreciate the fact that the traffic problem is one which requires proper financing and is really as much a function of the city as the policing and cleaning of the streets, the fighting of fires, the teaching of children, health administra-

tion and the other city duties which have been undertaken since the very beginning of city life.

The city administration, therefore, has two responsibilities in regard to traffic: first, to relieve conditions as much as present circumstances will permit and second, to gradually educate public opinion to the point where the requirements of traffic will be appreciated in their true proportions and adequate funds and co-operation provided. As this latter responsibility is one the entire fulfillment of which will require years of definite effort, the first is the one which demands immediate attention. It is expressed in the subject upon which I have been invited to speak—namely, "How to Solve the Traffic Problem at the Least Expense." As this problem is an ever changing one, its complete and permanent solution can never be obtained. Frequently the cheapest methods are in the end the most expensive. Permit me, therefore, to change the subject slightly to read, "How to Provide the Greatest Possible Relief to Traffic with the Funds Now Available or Possible to Obtain."

It was with this question in mind that your organization proposed, early last year, that a traffic and public safety demonstration be made in some city in New York. About the same time the Metropolitan Life Insurance Company, insuring more than twenty-three million lives in the United States and Canada, most of whom are residents of cities, determined to give definite study to the traffic problem, particularly as it affected public accidents.

Arrangements were made for your Conference and the Metropolitan to join in conducting a demonstration and the city of Albany was selected. Your late President, William S. Hackett, who was Mayor of Albany at the time, was deeply interested in the undertaking and gave to it his full support and co-operation.

Early in January, Mayor Hackett appointed a Traffic Commission, composed of the City Engineer, the Corporation Counsel, the General Manager of the Traction Company, the Traffic Manager of the Delaware and Hudson Company, the Signal Engineer of the New York Central Railroad, a representative merchant and the Secretary of your Conference, who was named vice-chairman of the Commission. I had the pleasure of working with this body in a consulting capacity. The Traffic Commission as thus appointed was continued in office by Mayor Thacher. It has completed and submitted a series of ten reports dealing with the traffic situation and recommending a continuous public safety campaign. In order to make the findings of the Commission available to other cities as an indication of the procedure adopted, the principles involved and the type of information obtained, the reports together with explanatory notes and drawings are being published by the Metropolitan for distribution.

It is hoped that this publication will prove of value as a guide to other cities desiring to make a study of the local traffic problem. It is my intention at this time to describe the work in Albany.

The scope of the study made by the Albany Traffic Commission is indicated by the titles of the ten reports which were submitted to the Mayor, as follows:

Analysis of Street Accidents.
Parking and One Way Streets.
Routing of Through Traffic.
Boulevard Stop Streets.
Automatic Traffic Signals.
Regulation of Bus Stops.
Regulation of Pedestrian Traffic.
Enforcement of Regulations.
Permanent Traffic Organization.
Plans for Public Safety Campaign.

These reports were forwarded individually to the Mayor, as soon as completed, and were released by him to the local press for immediate publication. The public was thus advised of the work as it progressed.

In making the traffic study the Commission felt that the problem was essentially an engineering one and that recommendations for its effective solution should be based on accurate facts and engineering principles. It proceeded, therefore, to gather such material as was deemed essential.

A report of automobile accidents in the city for the year 1925 was obtained from the Bureau of Motor Vehicles of the State. This report was furnished on the form utilized by the Bureau in preparing monthly and annual reports of the accident experience of the state and of individual communities. Similar reports may be obtained by any municipality in New York State. From this report an analysis showing the most important phase of the public accident problem was prepared and submitted to the Mayor. The following facts developed by the analysis are of interest. Sixty-three per cent of the persons killed and fifty-six per cent of those

injured in Albany as a result of automobile accidents were pedestrians. Forty-six per cent of the automobile accidents occurred on straight level streets or roads between intersections; seventy-five per cent occurred on dry streets or roads; seventy-six per cent during clear weather and sixty-two per cent in daylight. In other words, about sixty-five per cent of the accidents happened under the most favorable driving conditions possible. Only three and seven-tenths per cent of the vehicles involved in accidents were reported as having defective equipment. Twenty per cent of the motorists who had accidents during the year were charged with violations of traffic laws and forty-three per cent were reported as being inattentive. These figures proved that the larger proportion of automobile accidents are the result of human rather than mechanical failure. They clearly indicated the need of public safety work to arouse a greater interest among the citizens and to obtain their co-operation in making the streets safe.

At the request of the commission the Bureau of Motor Vehicles prepared a spot map on which was shown the location of every automobile accident occurring in the city during the year. The general type of accident and its relative severity were indicated by different colored pins. The bureau is in a position to prepare similar maps for other cities in New York State upon request from the proper officials.

In order to obtain actual facts regarding the quantity of traffic moving on various main thoroughfares, the variation of traffic during the day and the relative importance of each type of vehicle, the commission considered it essential that a traffic count be made. With the assistance of the city engineer, thirty-six significant locations were selected and arrangements made with the local council of the Boy Scouts of America to place boys at these locations in order to count the traffic flow.

Convenient sheets were printed for the use of the boys in tallying the count. These sheets provided for the counting of traffic by quarter-hour periods, by direction and by type of vehicle. The count covered the period from 8 A. M. to 6 P. M. and were made on a Thursday and Saturday in the early spring before the start of the heavy summer tourist travel in order to indicate the movement of vehicles local to the city and the immediate surrounding country.

The information thus obtained assisted the commission to determine the relative intervals of timing for the suggested automatic signal system and proved to be an aid in the preparation of a report relative to the rerouting of through traffic. From the traffic count figures a traffic flow map was prepared, showing in a graphic manner the streets of greatest travel and the main routes used by vehicles entering and leaving the city and approaching the business district. Another count is planned during the summer to check the correctness of the timing system and the efficiency of the rerouting recommendations.

Feeling that effective traffic control was dependent in large part upon the attitude of the general public and the co-operation which the city authorities could obtain from it, every effort was made to instill a feeling of confidence in the public mind and to request suggestions from the persons most interested in the particular phase of the problem under consideration. On several occasions members of the Chamber of Commerce traffic committee were invited to attend the meetings of the commission, at which time the work of the commission was explained in detail and the approval and support of the other committee obtained.

Due to the congested condition of the business district it was decided that first attention should be given to the need and designation of one-way streets and to the parking problem in this area. A plan was prepared and included in the commission's first report, in which certain narrow streets were selected for one-way traffic only, in such a way that the direction of movement would be continuous throughout the length of these streets and would allow for expeditious movement around the near-by territory.

After considering the needs of the merchants and also the effect on congestion, certain locations were designated where parking should be prohibited. It was recommended that parking within the business section of the city be limited to one hour within any one block bounded by two intersecting streets and including both sides of the street upon which the vehicle is parked. The commission felt that a shorter period would be of little additional benefit and would cause a greater agitation of traffic, whereas a longer period would considerably reduce the available parking capacity.

Parking or stopping within the city limits, except for an emergency, was prohibited within ten feet of a fire hydrant, unless the vehicle is in charge of a competent driver; within fifteen feet of the

extension of building lines at street intersections or fifty feet where the loading of street cars and buses is permitted within fifteen feet of either end of a safety zone. Parking was prohibited in front of, or within fifteen feet of either side of the entrance of a place of public assembly; across any private driveway; within three blocks or 600 ft. of a a burning structure; in front of all public and parochial schools between 8:00 A. M. and 5:00 P. M. on school days and on all streets from 2:00 A. M. to 5:00 A. M. without special permission from the police department. A map was prepared showing graphically the suggested one-way street and parking regulations and this was published in the local press. It was interesting to note that at a hearing held subsequent to the publication of this map, only four complaints were made, and these were easily handled. Subsequently, the commission's recommendations just referred to were unanimously passed by the common council.

In several instances, suggestions were made for the widening of streets, by moving the curbs back where the sidewalk widths permitted. It was also recommended that white lines be painted or placed on the street suface to designate cross walks within the main business district, to indicate the place where vehicles should stop in the rear of safety zones, and to designate the parking places where right angle parking is permitted. Plain and conspicuous signs, located where they may be seen clearly, were recommended to designate one-way streets and parking limitations.

Albany being located on many main thoroughfares receives a very heavy through tourist traffic from early spring until late fall, which heretofore had caused considerable increase in traffic congestion in the business district. A number of merchants stated that they would prefer having the streets in the business district kept open for local traffic than to have them crowded with through non-stop traffic. The commission felt it advisable to recommend a series of through route streets which would divert this type of traffic around the business district. In its report dealing with this subject the commission recommended that clear signs be posted in such a way as to encourage through motorists to utilize these routes, while at the same time indicating the direction to the hotels and business district.

The fact that certain highways in a city are of paramount importance in a traffic system and that vehicles operating in and entering them need proper protection led the commission to recommend the adoption of boulevard stop street or main arterial highways. It was felt that the reasonable use of this plan would expedite traffic and assure greater safety. The necessity for the rigid enforcement of the speed and right of way regulations provided in the state law, the adequate posting of intersecting streets and provision for breaking the flow of traffic in the boulevard streets by means of traffic signals was stressed by the commission.

In addition to designating certain streets as boulevard stop streets, it was recommended that boulevard stop signals be placed at certain other intersections where the accident spot map indicated a number of serious accidents had occurred in the past. Feeling that the success of the boulevard stop plan depends upon the distinct and adequate designation of the stop locations, as required by state law, the commission recommended that a signal, to be illuminated at night, be placed inside the curb, on the right side of each intersecting street near the intersection, and that a white line be painted or placed on the street surface, indicating where the stop should be made. The following inscription was suggested for the signals:

Boulevard Street
STOP
then
GO

After studying the flow of traffic as indicated by the traffic count recommendations were made that automatic signals be placed at a number of intersections in the business district and in the outlying territory. At most of these places a standard form of signal was suggested but at five locations it was necessary to make a thorough study of conditions and to offer definite recommendations. Maps of the intersections were prepared and the various traffic routes laid out upon them. A system of lights was then designed, adequately to control these various lanes. These charts, together with blue prints of the suggested layout, were submitted with the report.

The commission recommended that a two-light system be used for all automatic signals, feeling that this plan provides for greater safety than does the three-light system. It was suggested that in place of the amber light used in the three-light system to indicate the clearance interval, arrangements be made to

lap the signals so that a red light will show in both directions at this time.

A suggested ordinance, patterned after the model regulation suggested by a special committee of your conference, was submitted for the regulation of pedestrian traffic. Briefly, it stipulated that a pedestrian should obey the traffic signals and should only cross the street at street intersections, within the main business district, and in streets where surface cars operate. It also included a series of safety suggestions for pedestrians.

In its report regarding the enforcement of traffic laws, the commission emphasized the fact that no matter how perfect and practical the traffic regulations were they would be useless unless rigorously and continually kept in force and that no matter how competent the police might be the efficiency of law enforcement would be impaired if the court was not kept sufficiently clear of minor cases so that it could co-operate effectively. It was proposed, therefore, that the police be instructed to make arrests for only the most serious violations which were grouped as follows:

1. Failing to stop for surface cars while taking on or discharging passengers.
2. Failing to report accidents.
3. Minor operating automobile.
4. Not having proper license plates.
5. Operating automobile while intoxicated.
6. Reckless driving.
7. Speeding.

For other infractions of the traffic law it was suggested that the drivers be instructed to report at police headquarters where, if it were the first offense, the officer in charge would firmly impress on the mind of each person that he had violated a regulation, explain the violation and dismiss the person with a warning that a second complaint would necessitate court action. It was felt that this would considerably relieve the congestion in the police courts. It was also recommended that the Department of Public Safety hold a traffic regulation class for the instruction of policemen. The following subjects for use in this class were suggested:

1. Provisions of General Highway Traffic law.
2. Provisions of State Motor Vehicle Law.
3. Provisions of Local Traffic Ordinance.
4. How to detect illegal headlights.
5. Uniform hand signals for traffic officers.
6. Commission's recommendations for law enforcement.
7. Reporting accidents.
8. Strict but courteous enforcement.

One of the causes of traffic congestion in Albany is the stopping of buses opposite safety zones and places where street surface cars take on and discharge passengers. The surface cars now stop at the near side of an intersection and it was recommended that buses be required to stop at the far side, except at designated locations where conditions make this necessary. In such cases they will be required to stop fifteen feet behind the safety zone or street car stop.

The need of a continuous engineering study of traffic conditions was emphasized repeatedly throughout the deliberations of the Traffic Commission, and subsequent to the other reports, it was recommended that the city create, as soon as possible, a permanent traffic bureau with a single head, appointed by the mayor, and suggested that this bureau be assisted by an advisory commission consisting of the chairman of the City Planning Commission, the Commissioner of Public Works, the Commissioner of Public Safety, and two citizens interested in, and conversant with, the problems of traffic.

The final report of the commission set forth the need for an organized and continuous public safety campaign. It was suggested that this work be conducted under the general direction of the Traffic Commission or the permanent Traffic Committee, when the same was appointed, that the existing civic, service and commercial organizations of the city be requested to co-operate with the movement and that each one be asked to undertake some specific portion of the program as a part of their regular organization work. The following activities were suggested for the campaign:

1. Monthly safety posters.
2. Safety instruction in the school.
3. Safety on the playgrounds.
4. Conduct of a course in safe and efficient driving for drivers of commercial vehicles.
5. The use of safety films in news reels in moving picture exhibitions.
6. The organization of a safe drivers' club.

7. The co-operation of the churches.
8. The inclusion of safety on the program of all organizations.
9. The conduct of community safety rallies.
10. The conduct of an industrial safety course for superintendents and foremen.
11. The preparation and distribution of interesting safety literature directly into the homes.

In thus describing the work of the Traffic Commission in Albany, I have endeavored to indicate the general principles which were followed. In order to produce successful results the entire public and traffic program of any city must have the active co-operation of all the various interests in the community. The Albany study indicated how this co-operation may be obtained, and by procuring the actual participation of existing agencies it showed how the program may be carried out at small expense to the city and without the necessity of raising a large central budget.

THE NEED FOR MORE HIGHWAYS

By L. I. Hewes, Deputy Chief Engineer, U. S. Bureau of Public Roads

Highway construction and upkeep have only one end, namely, to serve transportation. Highway transportation in America today is measured by the presence of 20,000,000 motor vehicles, and on an average of 14 miles travel per gallon of gasoline there would result an annual average radius of travel of not less than 6,500 miles. This is a tentative figure. In California the average is higher, probably 7,000 miles. The annual operating bill for the country is doubtless close to $9,000,000,000; it may be more. The annual expenditure for all rural highway purposes is therefore about 10 per cent of the total bill of $10,000,000,000 for highway construction, upkeep and operation. It is this high operating cost, which is nine times the cost of construction and upkeep, which shows clearly the need for more highways.

These traffic figures take no account of the reason for the presence of 20,000,000 motor vehicles upon our highways. It is not the business of the engineer nor of the contractor to investigate at this time the economic or philosophical principles which cause the presence of these motor vehicles and the huge bill for their operation. We are confronted with the condition, and to engineers and contractors the condition demands action. We are concerned with the direct question of reducing the operating bill and ultimately of reducing the entire highway transportation bill, both for operation and construction and upkeep. We must look forward to the time when the highways will require more upkeep and less for construction. But we must first look forward to a reduction of the $800,000 difference between operation and upkeep. However, since the rate of increase of automobiles and of the wealth in the country constantly changes the total annual figure, it is perhaps better to say that we look forward to a reduction in the 9.1 ratio now presented by operating costs and highway production costs.

We know as a basic principle that improved highways are reducing the cost of running automobiles and motor trucks. We know that the 5,000-mile life of tires has been extended to 15,000 miles or more by highway improvement. It is probable that the wear and depreciation on tires is as directly traceable to poor road conditions as in any other single operating item. We know that the machine wears out faster on poor roads than on good roads, and we have a measurable direct evidence in the behavior of the tires. The operating costs of motor vehicles is made up of a number of items and the cost of these items has been variously studied. Some of the costs are independent of road conditions. Such for example are items of insurance, garage and interest on investment. Costs for fuel, rubber, repairs and depreciation are directly chargeable to the road.

Very few cars spend less than $100 per year for gasoline. The total gasoline bill for operating our country-wide motor vehicles is therefore nearly $2,000,000,000. A large mileage of the operation which requires this gasoline is now on improved highways and it is impossible to segregate economic or advantageous operation from the wasteful or disadvantageous operation. Probably never will we positively fix the loss in excess gasoline costs due to poor highway surface. We are at liberty to guess that some of the motor vehicles do not operate on good highways. We have in America nearly 3,000,000 miles of rural highways and only about 500,000 miles or one-sixth, can be classed as really improved. We thus have 2,500,000 miles of unimproved highways, and we know that motor vehicles still operate on these unimproved roads. The federal aid system of interstate and inter-county highways totals, theoretically, about 200,000 miles, or 7 per cent of the total mile-

age on record in 1921. It is hoped that this mileage will serve nearly 80 per cent of the people. This mileage is about two-thirds completed, and incidentally 65,000 miles have been built without any federal aid. On the main highway system of America it is evident then that there are still to be improved about 78,000 miles, and over this unimproved mileage there now operates daily and at a loss a part of the 80 per cent of the total automobile and motor truck traffic of the country. In other words, approximately one-third of the rural traffic, or about 27 per cent of the major prevailing motor operation, is probably moving at a disadvantage over unimproved roads. So it is consequently quite probable that every one of the 20,000,000 motor vehicles pays a mud gas tax of a little more than ½-cent per mile upon 25 per cent of its annual operating mileage. If this is so, the annual gas mud tax for the country would be close to $150,000,000.

To this gasoline loss, which is one of the items that measures the need for more highways, there must be added the loss of rubber, the wear and tear on the machine, the necessary repairs, and there then results an approximate measure of the unnecessary operating bill. It is sometimes held that the decrease in gasoline consumption on the improved highway as compared with the unimproved highway gives us the rating factor for the decrease in all costs. It may be that our $9,000,000,000 would therefore be decreased to about $6,300,000,000 annually if our highways were sufficiently improved to be operated at the minimum cost. At present we omit consideration of the 93 per cent of rural highways, mostly unimproved, over which 20 per cent of the motor traffic must still move at economic loss for an indefinite period.

A saving of $2,700,000,000 in annual operating costs of highways seems almost incredible, because the dimensions of the operating bill are themselves hard to accept, yet in a recent address at Detroit, Mr. Graham, secretary of the United States Automobile Chamber of Commerce, made the statement that the automobile manufacturing industry was now America's greatest industry. In other words, highway transportation is today served by the greatest manufacturing industry in the country for the rolling stock alone. What then cannot be said of highway transportation in general when we add to the motor production the activity of highway construction itself and its upkeep, and to that add all the other industries of motor transport proper? Truly the task of the engineers to bridge the gap between the science and the industry with respect to highway transportation is enormous. It is not impossible that $2,500,000,000 are yearly wasted because of the lag of highway improvement behind the demand to operate motor vehicles, and isn't it quite evident that we need go no further to demonstrate the need for more highways? We cannot escape the conclusion that the gap between the expenditure for operating the vehicles and the expenditure for establishment and upkeep of the highways must be reduced.

We may apply ourselves intelligently then to the problem of educating the public to the waste that unimproved highways mean. Laws must be passed in keeping with modern conditions. Granting that legislation lags behind science, the responsibility of the engineer and of the contractor, who is the indispensable ally of the engineer, is correspondingly increased. If we examine the set-up of money that is going into America's highway today we find that with 1924 as representative, the automobiles paid $300,000,000 in gasoline tax and license fees and that most of this money was applied to highways, and a large part was administered by state highway officials.

There is no question that legislation is needed in many sections to increase the amount of such fees. It is fair to state that the consumers of automobiles, or the operators, paid also a large federal excise tax on new machines and parts. In fact the automobile and motor truck operator paid in 1924, on the basis of his total taxes, nearly half the rural highway bill. Without doubt there are many defects in the present diversified system of taxing the motorist. We have been required to set up a budget for highway expenditures four-fold in 10 years. It is not surprising that there are defects and discrepancies in our tax rates. It is going to require much hard work actually to determine the advantageous and fair rate of taxation for highway purposes that the motorists under all the varying conditions in the forty-eight states should pay. The outstanding evidence is, however, that the motorist as an individual is not opposing his license and gasoline taxes. He is violently in favor of improved highways and when he is convinced that his taxation is for highway purposes he is content.

There are items of highway improvement that partake of the nature of per-

petual community investment and give rise to the question of the fairness to the automobilist if he is reqired to pay 100 per cent for such items. We can apply, in various ways, time-tried formulae of taxation according to the benefit theory and the faculty theory of capacity to pay. There is no question that primarily the automobilist is the direct beneficiary of the taxation of his machine when exclusively for road purposes. There is no question that another class of beneficiaries exists, namely, the land owners. There is a great question, however, as to whether or not the group of land owners and group of automobile operators are distinct. As the degree of saturation is approached, as in California today, these two groups tend to become less distinct, in fact to become identical. With a ratio of 3.4 people per motor vehicle in California, it is difficult to imagine that the land-owning class does not also own the automobiles.

Perhaps the question of the method of financing highways, which is after all the form in which the need for more highways is most frequently stated, is not a question as to what name to give the group of taxpayers; it is rather a question of deciding what form to give to the financing. There are able advocates of long-term bonds and there are notable examples of such methods, particularly in New York. The old argument that the road wears out before the bonds mature is scarcely longer tenable. Even if the pavement or hard surface were to considerably depreciate under modern traffic in spite of the best maintenance, it is probable that the appreciation of the well-built and designed roadbed and drainage structures as a public utility for the transaction of business is greater than the incidental depreciation of the surfacing. But many States have found it much cheaper to shorten the term of bond, and 20-year deferred serial bonds are consequently more frequent.

The grade crossing elimination program is retarded in many States because of the pressure for construction money. Without doubt permanent grade separation structures are reasonably permanent investments and would be a safe asset against loans for highways. The pay-as-you-go plan from automobile revenues could in many cases be wisely supplemented by judicious borrowing for grade elimination structures. Such structures become a part of the highway equipment and they are largely in the nature of an investment of the public at large for comfort and safety. A notable case in point is the recent issue of $300,000,000 in New York State to eliminate such crossings, with the proviso that the State may advance a part of the railroad's share, to be later reimbursed.

The entire question of taxation and rate making for highway purposes is still in a rather crude stage of development. Experience in borrowing for highways is also comparatively new. Enormous sums have already been borrowed by States and counties and there have been some instances of bad arrangement of the loan but on the whole the expenditure of the proceeds of highway bond issues of all kinds has been economically sound and very profitable.

It should be noted that highway engineers have until recently never had complete measure of highway traffic in any State. In California probably as much or more is known about the volume of traffic in detail, and its characteristics, as is known in any State of the Union. It must be remembered, however, that the highway engineers do not control traffic and they have never had enough money to build enough highways to get ahead of the demand by the public for more service.

The public, moreover, does not see the invisible but real income produced by highway operations, whereas it is highly conscious of the increment of increased taxation for highway bond requirements. It is the very fact that highway borrowing has been profitable that should warn us not to over-extend such methods of financing.

EFFICIENCY IN CONCRETE ROAD CONSTRUCTION

By J. L. Harrison, Highway Engineer, Bureau of Public Roads, Washington, D. C.

(Address before 1926 meeting of Indiana Highway Constructors, Inc.)

Before beginning this address may I take the liberty of thanking you for the honor you have shown me in extending an invitation to be present this afternoon. I deem it an honor because it is an expression of your confidence in the value of the studies the Bureau of Public Roads is making of the problems of the contractor.

We have hoped that the results of these studies would interest contractors, so the invitation to be present here this afternoon was particularly gratifying, for it

was, you may be interested to know, the first official recognition of the value of this work by a contractors' organization, and, as such, I trust it will prove but the beginning of a new relationship between the professional engineer as such and that group of gentlemen of whom you are members who carry the heavy risk and the large financial burden of giving concrete expression to the increasing volume of plans for public improvements.

There are many phases of our work on which it would be a pleasure to speak this afternoon, but, of them, none is more interesting than the problem of developing efficiency in concrete road construction. But as concrete road work is a somewhat limited field an effort will be made to discuss this matter from a standpoint which is broad enough to be of interest to all of you.

Now, every construction operation is an assembly of equipment for the purpose of producing a product of some sort —in this case, square yards of concrete pavement. In short, every construction job is a manufacturing operation. But, in any manufacturing operation, it is but axiomatic that the amount of labor which will be needed is governed by the equipment which must be used and the methods employed rather than by the rate at which the product is turned out. You have, then, on most jobs, instead of a payroll which varies with the output, a fixed equipment, standard methods, practically a fixed force, and with these practically a fixed payroll, but a variable production.

Now, as the equipment selected and the methods used vary a little from job to job, the payroll will also vary a little and sometimes too much equipment is used. More often too much labor. These are the points where it has been customary to look for waste and it must be observed that waste often can be found here. An old-fashioned crane is in use and as a result two or three extra men are required. Two small hoppers are used with two operators instead of a large hopper and one operator, or, on the methods side, the concrete is dropped from the bucket in a pile and four or five men are used to spread it where two could handle it if it were properly spread by the mixer operator. There is nothing to be gained by increasing the number of these illustrations, for the point will be clear enough—that a man here and a man there, whether required because of the nature of the equipment selected or by the methods used, or through sheer excess in the use of labor, soon adds to a total which inevitably increases payroll expenditures by an imposing amount. There is here then a field it will always pay to search carefully if low cost is to be secured.

But, while this field is important, its importance is small as compared with the other side of the cost structure—the production side. If $400 a day is taken as the cost of running a modern paving job—labor $200, depreciation $100, operating expense and overhead $100, an increase of $50 a day in the labor item, only increases production cost 12½ per cent. This is very little as compared with the effect a falling off in the rate of production will have.

A modern 6 bag paver can produce 48 batches of concrete an hour and still meet the requirements imposed by the standard specifications governing a one minute mix. This is practically 130 ft. of standard Maricopa section pavement per hour and is the maximum output which can lawfully be had under prevailing one minute mixing time specifications. During a ten hour day the full utilization of the working time can then result in the lawful production of 1,300 ft. of pavement. Under similar circumstances full production from a five bag paver is 1,080 ft.

But if $400 a day is the cost of production, with proper equipment, proper methods, and the correct amount of labor (and it makes no real difference whether this figure is exact or not for it will do as well as any for purposes of illustration) the basic unit production cost can be as low as $400 divided by 1,300, or roughly, 30 cents a running foot, which is 15 cents a square yard. This 15 cents per square yard is, then, a sort of standard—a figure below which cost cannot be forced while present specification hold, and while the methods and the machines of today continue in use. On the other hand, if, by the use of poor methods, or the use of obsolete equipment, the daily cost of operation rises to $450—and this would be rather a wide variation, though wider have been observed—the unit cost of manufacturing the pavement would only be increased to a shade over 17 cents a square yard—a matter of only 2 cents per square yard.

But—and here is the crux of the whole matter—if your production falls to 1,000 ft. a day, your manufacturing cost rises to 20 cents a square yard; if it falls to 700 ft. a day, your manufacturing cost rises to 28 cents a square yard; if it

falls to 500 feet a day, manufacturing cost rises to 40 cents. This is not an uncommon average rate of production, but the unit cost of production is now nearly three times what it would be with full production. But this is not all. I have, myself, seen two jobs this year where production did not much, if any, exceed 300 ft. a day—manufacturing cost $0.67 a square yard—and one job that averaged less than 200 ft. a day—manufacturing cost at the astonishing figure of $1.00 a square yard. This is nearly seven times what it would have been under full production.

I greatly wish I could paint this picture in terms so clear that none could fail to grasp the conception of it, I wish to leave with you—the conception of labor cost, of equipment depreciation, of operation and of overhead as generating each day work is done, a cost which in its total is just about as uniform and just as inevitable as the job foreman's salary. Every day the job runs the foreman must be paid and every day the job runs these expenses must be met. His wages do not vary from day to day and neither do these expenses vary in any considerable degree. They are, in short, a constant. But, if this is admitted, it is obvious that when production falls to one-half of what it can be made, manufacturing cost per unit produced will be twice what it ought to be. This is as unavoidable as that two and two make four, and its effect on profit more destructive than the calamities we call acts of God.

May I add that without a single exception the contractors I have met who were in financial difficulties were there, not because their daily operating cost was high, but because their daily production was low. Sometimes the condition was beyond their control. A matter of design, perhaps, as often happens in grading work. But whatever the cause its effect had, in these cases, been the ultimate destruction of both profit and capital. I refer to this merely to emphasize the tremendous importance of production as a factor in the profitable execution of construction work.

With this concept of some of the general aspects of construction work in mind, the natural question is, why is output often so low and what must be done to correct it?

To get at this let us go back to the working day. Commonly it is from 8 to 10 hours. Let us assume that it is 10 hours. But production is the product of a rate and a time, and full production can be had only by obtaining the full rate of production over the full working time. This at once suggests the inquiry—Is the full rate of production secured and is the day fully utilized?

On most jobs there are, of necessity, a good many hours lost every month because of weather conditions. However, after taking these out because the weather is uncontrollable and its effect on a field job largely so, the studies the Bureau of Public Roads has made indicate that of the 10 working hours in a working day, few contractors utilize over 9 in actual production. Many never average over 8, quite a number find it somehow impossible to use more than 7 and occasionally the average utilization of the working day in actual production falls below 6 hours out of 10. Very few contractors will believe that they or their superintendents waste time. This is quite natural. However, to such it is only possible to recommend that from day to day an accurate account of the time the mixer is in operation be kept. The result will often prove a surprise. There is one case in our records in which a good superintendent kept his mixer running 225 hours—22½ days out of a month, while a poor superintendent on a job not very far away only produced concrete during 150 hours, equal to some 15 full days. The loss of time due to weather was about 2 days on the first of these jobs and about 2½ days on the second. If we take 26 days as a normal month the first superintendent dropped one day while the second dropped nine. This is rather an outstanding illustration of the difference in the utilization of working time that is to be found from job to job in this country today. Nor is the second case the worst that has been encountered. We have had some considerable contact with one job on which with two 5 bag mixers on the work only a little over six miles of pavement was laid between May 1 and Nov. 15 of this year. Sheer waste of perfectly good working time was the outstanding cause of this low production.

There are many causes which reduce the utilization of the working day. The men often are permitted to go to and from the work on the boss's time. Often no effort is made to start the mixer "until after the whistle blows," and 10 or 15 minutes are lost here. Perhaps the material supply is not started early enough to reach the mixer by starting time. Often bad weather is made an excuse for "knocking off" before it is, in fact, a

reason for so doing. All of these things lose a little time—not much perhaps—but in their accumulation a sum sufficient to play havoc with high production. After all, the working day offers only 600 minutes in which to produce. If one is lost, it is lost forever. There is no such thing as "catching up" lost time. Tomorrow is another day and it must carry its own burden of production. No—the minutes that are dropped are irrevocably lost and every time one is thrown away, you, as a contractor pay, whether you realize it or not, in profit obtainable when you took the job, but now gone beyond recall.

Then, too, and this is the unpleasant side of the work of a production engineer, it must be added, though one finds no pleasure in doing so, that there are in this field today far too many superintendents who are lax—who produce what it is comfortable to produce when the conditions are favorable, but who do not succeed in so planning their work, in so keeping up their equipment, in so looking after their material supplies that every working hour can be utilized. Such men should be replaced by more energetic men—men with more capacity as organizers—more ability to avoid difficulties by devising ways to meet before they arise.

I have often wondered whether the real value of a real superintendent is fully appreciated. Take the two jobs referred to a moment ago. If the cost of operating a concrete paving job is $400 a day, it is $40 an hour. Your job doubtless will yield a somewhat different figure, but this one will do as well as any for purposes of illustration. Now, this problem can be worked two ways. We can assume that the poor superintendent was properly paid and show how much more the other man was worth, or we can assume that the good sperintendent was properly paid and show what a loss the poor superintendent involved. Let us follow the second course. The superintendent on the job which produced concrete during 225 hours was one of the best concrete highway superintendents in the United States. I don't know what he was paid but let us say $1,000 a month. Perhaps he wasn't paid that much but whether he was or not, I am willing to testify that he certainly was worth that much. The other superintendent, the man who during the same month and under conditions no more difficult, only obtained 150 hours of production, though he worked parts of about the same number of days as the first superintendent was 75 hours behind at the end of the month. This loss of production was worth 75 times $40 or $3,000 to the contractor who employed him. He was, therefore, during that one month worth $3,000 less than the first class superintendent on this count alone. Probably the second superintendent was working for from $300 to $350 a month. I really do not know. But to have left the contractor who employed him as well off as the contractor who had the really first class superintendent this man should have paid the contractor a couple of thousand dollars a month to hold his job!

It is not necessary to amplify this matter to emphasize the fact that "cheap" superintendents are one of the most expensive investments a contractor can make. They are an outstanding cause of the prevailing under-utilization of the working day, and if high rates of production are to be attained, they must either be considerably developed or replaced.

It has been shown that production is the product of a time and a rate. Under such a condition it is apparent that the amount produced within a given period will be reduced as just shown by any loss of time. But it will also be reduced by any failure to maintain the proper rate. Maintaining the proper rate of production is, therefore, about as important as utilizing the whole of the working day. For almost any of the standard pavers full production under a specification requiring a one-minute mix is 48 batches an hour. This will lay practically 130 feet of Standard Maricopa section, 18-ft. pavement, if a six-bag batch 1-2-3½ mix is used. Under the same provisions a 5-bag mixer will lay 108 ft.

As compared with these rates, the bureau's studies show that few contractors maintain a rate of production that exceeds 40 batches an hour. Rates averaging in the neighborhood of 35 batches are, on the whole, about as common and in occasional instances a rate of production averaging under 30 batches an hour has been found. In one instance a job was visited where production seldom exceeded 20 batches an hour, but this was so exceptional a case that it hardly should be more than mentioned. Indeed, it is mentioned only to show that the rate of production can fall very low.

But if such rates are found, the natural question is—what causes such rates—or, for that matter, any low rate?

An outstanding cause of low rates of production is failure to co-ordinate equip-

ment. The mixer is the producer. It can turn out a batch every 1¼ minutes—must do so, in fact, if full production is to be had. But to be able to mix a batch every 1¼ minutes the delivery equipment must deliver one every 1¼ minutes, the batcher must load one every 1¼ minutes, and the crane must put one into the batcher every 1¼ minutes. In short, the equipment must be so carefully balanced around the output capacity of the mixer that there will be no point at which any other equipment will hold up the producer—the mixer.

Going a little deeper, this not only means that the truck supply must be adequate and that it must be properly handled, but it means that the individual trucks should be properly designed and equipped. The speaker was looking over a slow job one day with one of his assistants and saw truck after truck take between 1 minute and 2 minutes to dump its load. Now, on the average, only about 40 seconds are available for this purpose if delaying the mixer is to be avoided, so these poorly designed, clumsily put together, home-made truck bodies were throwing away from 1/3 to 1 1/3 minutes—an average of about 50 seconds—with each load delivered. Simply having those trucks on the job automatically cut production from 48 batches an hour to 28 batches an hour!

The hoppers must have proper capacity and must be easy to operate. They must be so designed that they measure or weigh accurately and quickly and that they never jam. Home-made hoppers often cause delays. A case was observed last year where a contractor, in an effort to save a few dollars, had erected and was actually using a hopper arrangement from which it was impossible to obtain a load oftener than once every three minutes. He could not, no matter what provisions were made for other phases of his work, secure a production exceeding 20 batches an hour.

Illustrations of poorly selected plant, of improper plant arrangement, of positive inadequacy in some element in the equipment list—particularly in the number of trucks supplied—could be given in large number but this is hardly necessary in order to justify the blunt statement that much of the prevailing underproduction on concrete work—and the same applies to other classes of construction work—is due to the failure of those responsible to see that in all of its elements the plant provided is such as to make full production possible. It is entirely practical to determine with absolute certainty whether or not a specific list of equipment is in balance throughout and capable of developing full production under any specific job conditions. To make such a determination is one of the normal responsibilities of management and where it is not made or where the calculations prove to have been in error, the responsibility rests squarely on the management.

Let me say in passing that home-made plant commonly is expensive and as a matter of general policy should be avoided. The manufacturers of equipment do not necessarily provide machines of equal efficiency, but those provided are so uniformly superior to any that ordinarily can be produced on the job that it is almost always possible to show that money has been lost by the use of the home-made equipment. Do not look for such losses in the first cost or in the first cost plus the upkeep. They are to be found in the effect the home-made equipment has on the rate of output and here such devices often are astonishingly expensive.

The next point at which the rate of output can be affected is in the operation of the equipment. Can the mixer operator mix 48 batches of concrete an hour if it is delivered to him? If not, can your superintendent show him how to mix it at this rate? Can the crane operator move material fast enough to serve the trucks at this rate? Can the finisher operator put down the pavement at that rate? These are very pertinent questions for, if the equipment if properly selected and properly arranged for high production, it is still necessary that the operators on important machines shall be able to set the proper pace and hold it. Most operators will work willingly when they know how to work, but it has been the experience of the bureau's engineers that very few operators can obtain full production until a good many of the details of fast operation are explained to them with some care.

In dealing with this general problem, it must be added that for high production it is as necessary that the job operations also be brought into balance and kept in balance as that the equipment be coordinated. The mixer can turn out 48 batches an hour but to do so it must have a place to put the concrete. It can't be mixed and piled for future use! There must be prepared subgrade. There must

be forms. Steel and parting strip must be ready. The water supply must be adequate.

Back of the mixer, the puddlers must be able to handle the output, the finishers to finish it, the curing gang to cover and cure it and the form gang to recover the forms. Every one of these branches of a paving operation must be able to keep up to the pace set by the mixer for if it is not, the mixer has inevitably to be stopped until the slow gang can catch up.

There is, then, to be considered the amount of labor required, its arrangement and its training so that each unit in the organization can produce at the rate established for the mixer. Here again we squarely face a responsibility of management. There may be all the equipment the job needs. It may be perfectly arranged and splendidly managed. There may be enough men on the job, and those on the key machines may be fully capable of securing top notch output but if the form setters get behind or if the group in the cement house lags or if the subgrade gang fails to get the subgrade in shape, the mixer must slow down.

You all see the point I am trying to make—and it is just as vital on any other sort of construction work as it is on concrete paving work. A high output requires a high rate of operation and a constant rate of operation not only at the primary producer—in this case the mixer—but in every other unit of operation as well. To keep the various phases of the work running in harmony, to see that difficult work which will be encountered tomorrow will hold up production next week unless extra men or special equipment are provided or unusual methods adopted—in short, to think for the job and by correct thinking coupled with prompt and correct action to keep all parts of the job in harmony—this is an essential part of management and an absolute essential in high production.

Summarizing the situation, it has been shown that the failure properly to utilize the working day often results in converting a ten-hour working day into an eight-hour day or a seven-hour day or even a six-hour day. It has also been shown that the failure properly to co-ordinate equipment, to select the right kind of equipment, to arrange it properly, to train operators to handle important equipment correctly and to harmonize the output capacity of the various branches of the producing organization are basic factors in all low rates of output, and that, from these causes, output often falls to 40, 35, sometimes to 30 batches an hour, though 48 batches an hour are attainable. But the use, as an illustration, of 7 hours out of a ten-hour day is the use of but 70 per cent of the working time and production at the rate of 40 batches an hour is about 83 per cent of the full rate of production. The product of these—70 x 83—gives the output for the day as 58 per cent of what is possible—about 600 ft. of pavement with a 5-bag mixer and about 750 ft. with a 6-bag mixer. Similarly, the utilization of 6 out of 10 working hours is a 60 per cent utilization of the working day, and if the rate of production is 30 batches an hour the rate of production is 62½ per cent of perfect production. But if work is done during only 60 per cent of the time and then at a rate which is only 62½ per cent of what it should be, the daily rate falls to 37½ per cent of what actually is possible and indicates the condition prevailing where a five-bag paver only turns out about 400 feet of pavement a day, or where the six-bag paver is producing in the neighborhood of 500 ft. a day.

Perhaps this address should be closed at this point with a few general remarks on how best to get at the matter of improving production, but I shall not do this for it has always been my impression that the means of correcting such a condition as under production will be devised quickly enough once the fact of underproduction is clearly appreciated and its specific causes are thoroughly understood. So, instead of dealing with this matter, I will, in closing this address, refer to another matter which may be of equal interest to you—that little matter of inspection. Perhaps, being an engineer, I ought to tell you that quality must be preserved at all cost. As a matter of fact this is true, for without quality a much reduced value is secured from the expenditure of money either in public works or anywhere else. So we must all admit that quality is essential. However, the truth of the matter is that there is no necessary conflict between quantity and quality in production. I have personally seen concrete pavement of the very highest quality laid for month after month at a rate averaging over 96 feet an hour (5-bag batch) for every hour the mixer turned over. I have seen the best kind of concrete road work done at a rate which, for a week at a time, would exceed 100 ft. an hour, and I know of one job that this year poured 1,262 feet of concrete from a 5-bag mixer in 12 hours—105 1/6

ft. an hour—and the pavement into which it went is one of the outstanding pavements in that state. Cores from that pavement are testing over 5,000 lbs., and the smoothness of the surface is far above average. No, gentlemen, there is no necessary conflict between quantity and quality in production.

Wherein, then, does the inspection problem lie? My observation is that it lies in the fact that the injection of new ideas, the imposition of new methods and practices and the enforcement of unusual refinements tend to cause greater confusion than the project engineer commonly supposes. To modify an existing practice often presents problems in management which the engineer little suspects and reduces production more than most would suppose. It is at these points that the problem of inspection really is vital. It has been shown that high production is essential if low cost is to be secured, and from this it is apparent that whatever interferes with high production interferes with low cost. Our observations lead to the conclusion that the general tendency of inspection is to reduce output—almost never purposely but rather through the failure fully to appreciate either the importance of high production as a factor in low cost or the difficulty of managing a job where methods and practices are subject to frequent change.

Two comments on this situation seem pertinent. The first is that there is not a sufficiently general appreciation of the legal principal that the language of contracts must be interpreted in the light of the customs prevailing when and where they were signed. You are under no legal obligation to modify a well established practice which was generally accepted at the time your contract was signed, merely because someone has decided that a different practice would be better and that the words used in the contract could cover the proposed practice as well as the customary practice.

The second comment is that the real cost to you of executing orders that lie outside of the contract ought always to be determined and charged back to the party of the first part in your contract. To do this it is necessary to know not only what a normal cost would have been, but what the actual cost was—that is, how the order affected your rate of production, your cost of production, your plan of work for the job as a whole, etc. But this is a long story—far too long to tell here!

May I say, however, in closing that there are few things your association as such could do which would be of more value to you as individual contractors than actively to give expression in the technical press to the necessity for and the value of high rates of production if low costs are to be had, of the effect of inspection on the rate of production, of your legal right to be freed from changes in engineering policy which are retroactive, and your unquestionable right to complete compensation for all of the expense, including that resulting from reduced rates of output, which modifications in your plan of operations, the addition of extra work, the omission of parts of your work, etc., often involve.

Mr. Chairman, gentlemen, may I thank you again for the opportunity to present these matters for your consideration? It has been possible only to treat them briefly and, on the whole, sketchily. That is inevitable in any short address. But of the matters touched on, none seems to me to have the importance which lies in that one factor in your work—your production. The man who can keep it at a high point—and does—is the master of any situation which can arise in the construction field.

CONCRETE VS. TIMBER FOR HIGHWAY BRIDGE FLOORS

By O. L. Grover, Bridge Engineer, U. S. Bureau of Public Roads, Washington, D. C.

(From "Public Roads" for October, 1926.)

The renewal of plank floors on bridges is a large item in the annual expense of brige maintenance; and aside from its expense, which is heavy, wooden flooring is noisy and causes excessive vibration of the structure and objectionable jolting of traffic when improperly laid or in a worn condition. While treated timber is expected to resist decay for about 25 years, unprotected flooring has a service life of from 3 to 6 years only, depending on the amount and character of traffic; and on bridges which carry a large unsatisfactorily served at all times in spite of heavy outlays for repairs.

Figures obtained by averaging the cost of maintaining unprotected timber floors on several steel bridges over a number of years show what the cost of upkeep may amount to on bridges carrying main-route traffic. In the District of Columbia for a 30-year period prior to 1926 the average cost for repair and renewal was

about 3½ cts. per sq. ft. per annum, or about 70 cts. per lineal ft. for a 20-ft. roadway, while for a 10-year period prior to 1926 the average was higher chiefly because of changes in the amount and character of traffic. In general it may be said that the experience of the past 10 years indicates a cost of about 6 cts. per sq. ft. per annum, or $1.20 per lin. ft. for maintaining a 20-ft. floor on bridges carrying present traffic on through highways near cities.

Such costs are excessive. In the effort to reduce them and improve the service of the unprotected floor, where the strength of the bridge has been adequate to carry the added dead load, bituminous surfacing has been tried as one method. Another which has met with some favor is the addition of steel-plate traffic treads; a third is the addition of a longitudinal or diagonal layer of timber as a wearing surface; and the use of planed flooring instead of rough plank has also been given a reasonbale trial. The object of the latter method is to reduce wear by building a smooth floor, and this is accomplished by the uniform thickness of the planed flooring. The beneficial effect of this method, however, is gradually lost by reason of the wear and replacement of occasional pieces with new pieces, the depth of which naturally varies considerably from that of the adjacent flooring.

For a 20-ft. roadway the average unit prices of these are approximately as follows:

Bituminous surfacing 2 ins. thick, per lin. ft.	$5.55
Four lines of steel tread, 24 ins. wide by $\frac{5}{16}$ in. thick, per lin. ft.	8.96
Four lines of steel tread, 24 ins. wide by $\frac{3}{16}$ in. thick, per lin. ft.	5.60

It thus appears that the 2-in. bituminous surfacing costs $3.41 less per lin. ft. than the $\frac{5}{16}$-in. treads and 5 cts. less than the $\frac{3}{16}$-in. treads. But these comparisons are naturally affected by the relative prices of steel and bituminous materials, and since the former vary from 7 to 11 cts. a pound and the latter from approximately $1.75 to $3.50 a sq. yd. the relative cost of the two methods may vary considerably from the above averages which are based on steel at 8 cts. and bituminous surfacing at $2.25 a sq. yd. Whichever, under the particular conditions obtaining, may be the cheaper, it is probable that the reduction in the cost of maintaining the floor will be more than sufficient to pay for the covering. But the resulting construction is still open to some of the same objections which pertain to unprotected plank floors, and some of these are serious.

With these objections in mind Dr. J. A. L. Waddell declared in 1919: "Wooden floors on highway bridges are now obsolete," adding that "no modern bridge engineer should be guilty of designing or building any more of them." He gave as his reasons for these very positive statements the following three reasons:

"First. The ordinary plank floor supported on wooden joists is not strong enough to carry with safety the heavy, concentrated live loads produced by rapidly moving auto trucks.

"Second. The danger from fire is so great that it does not pay to submit the entire construction of the chance of destruction by the burning of the timber in the deck.

"Third. The upkeep of a wooden floor is far higher that that of a paved floor on a concrete base; and the difference in the future will steadily increase, because the cost of timber will rise with its augmenting scarcity."

Costs of Concrete and Timber Floors Compared

General adoption of the concrete floor, for which Doctor Waddell so emphatically declared seven years ago, has been retarded to a certain extent by the unsatisfactory experience with the older type, used extensively in and near cities, consisting of a concrete bed for block or bituminous surfacing carried by steel buckle plates. This was the type used before the adoption of reinforced concrete slabs, and it has proved to be expensive both to construct and to maintain. The defects usually noted are broken buckle plates, especially where the buckle is turned up, broken and loose concrete, and frequent expensive repairs resulting from the breaking up of the pavement and holes in the floor.

The reinforced slab design is not open to these objections; and in common with the older type it possesses the very desirable quality of rigidity which inspires the confidence of those who ride over it. To the engineer it also suggests the idea of heavier weight, and the first thought is likely to be that extra steel will be required to carry it, so much, perhaps, that the cost of the bridge with concrete floor may exceed the cost of a timber-floored structure. So far as the trusses and floor beams are concerned

this assumption is correct, but on account of the possibility of using deeper I beams for stringers and a wider spacing the saving in stringer weight may be nearly enough to compensate for the increased weight of trusses and beams.

To show the effect of using a concrete instead of a wooden floor upon the cost of actual structures of various types a number of cases are cited below in which comparative estimates or alternate bids on the two types of construction are available.

Case 1.—The structure consists of a steel viaduct on concrete pedestals and open abutment bents with riprapped embankment around the ends of the fills. It crosses a railroad track and a creek about 70 ft. wide. The entire structure is 79 ft. in length, with span lengths as follows:

	Feet
1 deck truss	65
2 deck I-beam spans, each 40 ft.	80
5 deck I-beam spans, each 32 ft.	160
2 deck I-beam spans, each 37 ft.	74

The roadway width is 20 ft.

For this structure alternate designs were made, one with a concrete, the other with a timber floor, both to carry a concentrated live load of two 15-ton trucks with 67 per cent of their weight on the rear axle, plus an allowance of 30 per cent for impact.

While the preliminary estimates indicated that the cost of the structure would probably be increased 2½ per cent by the concrete floor, the contract was let at no increase. One of the 40-ft. I-beam spans over the railroad track, as constructed, has its beams encased in concrete. This was not provided for in the alternate timber-floor scheme. The estimate of the cost of the concrete-floored structure complete, based on bid prices and including 10 per cent for incidentals, is $44,000.

Case 2.—Another bridge, now under construction, crosses a river the bed of which is erodible to a considerable depth. It is designed to carry two 15-ton trucks with 67 per cent of their weight on the rear axle, plus an allowance of 30 per cent for impact.

Alternate designs for concrete and timber-floored structures were made for two arrangements of spans including varying span lengths. For one arrangement the estimate of the cost of the concrete-floored structure was about 2 per cent higher than that for the wooden-floored design; for the other arrangement the concrete floor caused an increase of about 4 per cent in cost.

The first arrangement with concrete floor and a roadway width of 18 ft. is now under construction. It consists of three steel spans between piers 130, 190, and 320 ft. apart, and eight timber trestle spans, each 19 ft. in length, making a total length of 792 ft. The contract price for this structure, exclusive of approaches, is $180,000.

Cost Increased Only 2 Per Cent by Change from Wood to Concrete

Case 3.—In another case which recently came to the writer's attention a design was made for two spans with an 18 ft. roadway, one 180 and the other 200 ft. in length, with a concrete floor, after preliminary designs had been made for the same spans with a timber floor.

In each case the design was made for a concentrated live load of two 15-ton trucks with 80 per cent of their weight on the rear axle, plus an allowance of 30 per cent of the live load stress for impact.

For the entire structure the estimate showed a margin in favor of the wooden-floored design amounting to $617, the cost with concrete floor being $33,425. For the two spans the difference was thus shown to be about $1.63 per foot or less than 2 per cent of the total cost of the wooden-floored structure. For the 180-ft. span the difference was $1.58 per ft.; for the 200-ft. span about $1.67 per ft. The comparative estimates for the two designs of each span were as follows.

Case 4.—A bridge which is about one year old includes three 100-ft. spans with a roadway of 18 ft. It has a creosoted timber floor with four steel-plate traffic treads 24 ins. wide by $\frac{5}{16}$ in. thick. The actual cost of this structure at the prices bid for the several items was $8,362.49

Comparative Estimates of Cost of the 180-foot Span

1. WITH CONCRETE FLOOR AND A DEAD-LOAD ALLOWANCE OF 25 POUNDS PER SQUARE FOOT FOR SURFACING

Item	Quantity	Unit Price	Total
Concrete	88 cubic yards	$22.00	$1,936.00
Structural steel	214,000 pounds	.06	12,840.00
Reinforcing steel	12,500 pounds	.055	687.50
Total			15,463.50

2. WITH CREOSOTED TIMBER FLOOR AND A DEAD-LOAD ALLOWANCE OF 25 POUNDS PER SQUARE FOOT FOR SURFACING

Structural steel	210,000 pounds	$0.16	$12,600.00
Creosoted timber	25,800 feet b. m.	.10	2,580.00
Total			15,180.00

Comparative Estimates of Cost of the 200-foot Span

1. WITH CONCRETE FLOOR AND A DEAD-LOAD ALLOWANCE OF 25 POUNDS PER SQUARE FOOT FOR SURFACING

Item	Quantity	Unit Price	Total
Concrete	98.0 cubic yards	$22.00	$2,156.00
Structural steel	250,500 pounds	.06	15,030.00
Reinforcing steel	14,100 pounds	.055	775.50
Total			17,961.50

2. WITH CREOSOTED TIMBER FLOOR AND A DEAD-LOAD ALLOWANCE OF 25 POUNDS PER SQUARE FOOT FOR SURFACING

Structural steel	246,300 pounds	$0.06	$14,778.00
Creosoted timber	28,500 feet. b. m.	.10	2,850.00
Total			17,628.00

for each 100-ft. span as shown in the tabulation below.

Recently a bridge of the same dimensions, but with a concrete instead of a timber floor, was designed for construction on a forest road. In each case the design was made for a concentrated live load of two 15-ton trucks with 80 per cent of the weight on the rear axle, plus an allowance of 30 per cent for impact. Using the price bid for structural steel in the older bridge and reasonable prices for concrete and reinforcing steel it is estimated that the forest road bridge with concrete floor can be built at a price of $7,906.01 for each 100-ft. span as shown in detail below.

Comparison of these designs and the estimates below indicates that it probably would have been possible to substitute for the older design with wooden floor economically designed steel spans with concrete floor at a cost materially less than the price paid for the actual timber-floored structure with steel traffic treads.

The actual cost of the wooden-floored bridge per 100-ft. span and the estimated cost of the equivalent structure with concrete floor are as follows:

Bituminous Surfaced Concrete Costs Less than Wood with Heavy Traffic Treads

Case 5.—Two designs were recently prepared for the same span and roadway, 135 ft. and 20 ft. respectively. Each provided for a concentrated live load of two 15-ton trucks with 80 per cent of their weight on the rear axle, plus an allowance of 30 per cent for impact. One was made for a concrete floor, the other for a creosoted timber floor, each to carry 2 ins. of bituminous surfacing.

As shown by the following estimates of the cost of the two designs the one with a concrete floor may be expected to cost $165 more than the wooden-floor design, which is $1.22 per lin. ft. and only about 1¼ per cent above the cost of the wooden-floored structure.

With four lines of steel-plate traffic treads, weighing 9,400 lbs., estimated at the low cost of 8 cts. a pound the cost of this structure would be $13,151.90, or only $143 less than the structure with a concrete floor and bituminous surfacing. This estimate is based on the use of 24-in. by $\frac{3}{16}$-in. treads which is the usual practice, although it is doubtful if plates so thin will give good service for a long

1. ACTUAL COST OF 100-FOOT SPAN WITH 18-FOOT TIMBER FLOOR AND FOUR STEEL-PLATE TRAFFIC TREADS

Item	Quantity	Unit Price	Total
Structural steel	96,700 pounds	$0.0687	$6,643.29
Creosoted timber	10,400 feet b. m.	.098	1,019.20
Traffic treads	7,000 pounds	.10	700.00
Total			8,362.49

2. ESTIMATED COST OF 100-FOOT SPAN WITH 18-FOOT CONCRETE FLOOR

Structural steel	92,300 pounds	$0.0687	$6,341.01
Reinforcing steel	6,800 pounds	.05	340.00
Concrete	49 cubic yards	25.00	1,225.00
Total			7,906.01

Comparative Estimates of Cost of the Two Designs

1. WITH CONCRETE FLOOR AND 2-INCH BITUMINOUS SURFACE

Item	Quantity	Unit Price	Total
Structural steel	148,600 pounds	$0.069	$10,253.40
Reinforcing steel	9,300 pounds	.055	511.50
Concrete	72 cubic yards	25.00	1,800.00
Bituminous surface	292 square yards	2.50	730.00
Total			13,294.90

2. WITH CREOSOTED TIMBER FLOOR AND 2-INCH BITUMINOUS SURFACE

Structural steel	153,500 pounds	$0.069	$10,591.50
Creosoted timber	16,440 feet b. m.	.11	1,808.40
Bituminous surface	292 square yards	2.50	730.00
Total			13,129.90

time, especially if the corners of the plates are not bolted down with through bolts. If $\frac{7}{16}$-in. plates are assumed, the estimated cost becomes $13,609.50, which is $314.60 higher than the cost of the bridge with concrete floor and bituminous surfacing, a difference of more than 2 per cent of the total cost in favor of the concrete-floored structure. Without the bituminous surfacing the concrete-floored design would cost only $12,564.90 and would then have a favorable margin of $587 compared with the design with timber floor and thin traffic treads, a difference amounting to more than 4 per cent of the total cost.

Other Advantages of Concrete

It would seem that the above comparisons fully support the declaration by Doctor Waddell in favor of concrete floors from the standpoint of economy. From other points of view it would also seem that there might be added to the three reasons he enumerates, as the basis for his preference, several others, as follows:

1. That a well-shaped and watertight concrete floor so formed as to conduct the surface water to outlets away from the steel work gives better protection from the corrosive effects of weather and dirt to the steel under it.

2. That it is maintained with less labor and that its upkeep, therefore, causes less interference with traffic.

3. That the first cost of a concrete-floored bridge designed to carry heavy truck loads is generally but little more than a timber-floored design for the same live load. Even where prices are unfavorable to concrete the cost may only slightly exceed that of a timber-floored design.

4. A concrete floor increases the rigidity of the spans and in this respect acts as an aid to the bracing.

VALUE OF ORGANIZATION TO A BRIDGE CONTRACTOR

By Robert H. King, Bridge Contractor, Danville, Ind.

(Paper read at 1926 meeting of Indiana Highway Constructors, Inc.)

The quite generally recognized benefits of organization to any unorganized group of whatever kind, almost render unnecessary any effort to develop thought concerning such. It, therefore, occurs to me that, as a bridge contractor and a member of Indiana Highway Constructors, Inc., I may more profitably visualize for the benefit of my fellow contractor what the value of organization, as now developed in Indiana, could be made to mean to the bridge contractor as a class, if he would but become affiliated.

What phase or element of the industry with which the bridge contractor deals is, like himself, unorganized? Practically every industry in the country has its organization for promoting its particular business interests. These organizations are not something new, but have been in existence for many years, and large sums of money have been spent to maintain them. They have been profitable to their members or otherwise they would have ceased to exist. Modern business does not spend money for a long period of time unless there is a return on the investment. We have such organizations with which every contractor is quite familiar. To enumerate, there are the Indiana Sand & Gravel Producers' Association, Indiana Crushed Stone Association, Portland Cement Association, Indiana Lumbermen's Association, the Equipment Manufacturers' Association, and everyone is familiar with the great organization of the steel industry. Why have all of these organizations been formed. They were not formed to eliminate competition, but to produce a healthy competition. Before these industries got together to consider

their common troubles, theye were in a similar condition to that which confronts the constructor today, they were doing a vast business, but due to unhealthy competition, their books at the end of a year disclosed the fact that they had only done a large gross business—there were no net profits. But organization, to a large degree, has corrected some of the glaring faults, and through collective, constructive thought has enabled the many units forming the organization to show net profits at the end of the year. Obviously, they are organized to better their own conditions, and we, as bridge contractors, unorganized as we are, deal with these interests day in and day out without any advance thought to our own particular and individual problems.

In the early part of 1924 a group of highway contractors, recognizing the need for and value of organization, proceeded to form what is now known as Indiana Highway Constructors, Inc. In their vision and wisdom they saw fit to incorporate, as eligible to membership, highway, bridge and sewer contractors and others engaged in public improvements (excepting building contractors). Principally because the field of construction, whether it be in bridges, highways, sewers or what not, is fundamentally the same in all classes, and inequities which may prevail or occur are general, rather than confined to a class. With bridge contractors forming a comparatively small part of our present organization, it has been difficult to get a composite viewpoint of uneconomic conditions affecting the individual contractor, and yet time has been found, through organization, to attempt to correct some of the most glaring unsatisfactory conditions with which the bridge contractor is confronted.

In October of 1925 a committee of the association, including bridge contractors, made a study of state specifications as relate both to highways and bridges and made six distinct recommendations to the Bridge Department of Indiana State Highway Commission concerning revision of present provisions in specifications or additions thereto, each of which it was felt would be more equitable and would tend to better conditions for the contractor. An excellent example of the results of our work in this respect is afforded in the present revised clause in state bridge specifications concerning foundation piling, whereby the state assumed the responsibility of determining the length of piling. Previous to this revision the contractor was required to take all the responsibility, and if he bought his piling too short, it was a total loss, while if it were too long, he was required to lose that extra length, as he was only paid for what was left in the ground. Today the contractor is paid for piling in two units, one, a price per foot for furnishing the pile, and this includes every foot of pile placed in the leads; the other unit is a price per foot for driving the pile and includes only that part of the pile left in the ground. In addition, any piles which the contractor has been ordered to purchase that prove too short to use, are paid for at one-half the bid price for furnishing piles, and the contractor retains possession of them, thus preventing him from losing money on piling that he cannot use. If the association can accomplish this for the bridge contractors of Indiana, when it represents only two of them, how much more could it accomplish if it represented a majority of the responsible bridge contractors?

Since the meeting in October, 1925, of several committees of bridge contractors have been held at association offices for further consideration of the bridge contractor's problems, and on November 9th a general meeting of bridge contractors, without regard to membership in the organization, was held at association offices to arrive at additional recommendations to be submitted to the Bridge Department of the Indiana State Highway Commission for its consideration. Over and above the activity of the organization with reference to specifications appears its general study of competitive conditions and relative responsibility, all with the view of bringing about a more stable condition for those contractors engaged in public contract work.

Obviously the greater number of bridge contractors identified with organization, the easier would become the task of developing a composite viewpoint, the more representative would be the voice of the bridge contractor, and, consequently, greater would be the thought and respect afforded his opinion. To be organized along proper lines, functioning 365 days in the year in the interest of the industry and in a representative way, costs money—it costs more money than bridge contractors alone could afford to pay. If we were to endeavor to organize what may be termed "Indiana Bridge Contractors," assuming that there would be as many as 15 willing and ready to co-operate, the cost to each at inception would be approximately $650.00, and unless a gradual increase in membership were experienced

as the organization's field developed, it would cost proportionately more. It would be neither wisdom nor economy for us as bridge contractors to think of organization separate and apart from other phases of contract work.

I have read in our annual program the message from our president, and there are two paragraphs that I desire to quote. I feel that they bear directly upon the value of organization and afford an outstanding reason as to why the bridge contractors should become affiliated.

"The contractor is an essential and major factor in the construction industry. He is as necessary to the prosecution of a well-defined public works program as the governing body thereof. The benefits accruing to him by reason of an economic and equitable solution of his problems likewise accrue to the community. His interests and those of the community are, in the final analysis, inseparable. Organization makes possible an unanimity of opinion concerning such—and we are organized."

Again quoting from our president:

"This is the age of organization, and to be unorganized lays any industry or interest open to attack without the semblance of defense; it permits inequities to creep in and to grow pernicious unnoticed, it leaves economic issues unsolved and it retards progress and development wherever it exists. We cannot afford not to be organized."

I have been a member of this organization for two years. I have been active on committee assignments. I have observed its work, and I know that it is functioning in the interest of the construction industry. Speaking as "one on the inside looking out" I would urge the bridge contractor to become affiliated and to take an active interest in the work of the organization with the view of bringing about in a co-operative way the betterment of conditions in his own field of endeavor.

THE WINTER LETTING OF CONTRACTS

By Fred Cunningham, Cunningham Construction Co., 1801 Kentucky Ave., Indianapolis, Ind.

(Paper read at 1926 meeting of Indiana Highway Constructors, Inc.)

The Associated General Contractors of America, state organizations throughout the country, and trade journals in general, have advocated the winter letting of public contract work as an economic measure. That the award of contracts in the late fall and early winter months for completion during the construction season immediately following is to the advantage of the industry and the public alike is quite generally conceded, and yet in Indiana, our contracts are awarded as late in the year as June, July and August by the state, county and municipality, and in many instances the projects involved in these late awards carry a completion date of the same year.

There are two kinds of losses sustained by the public when and where projects under contract fail of completion in any one construction season. These losses may be classified as tangible and intangible, and both are present almost invariably under such circumstances. The tangible loss is that which results from the idle investment of money on which there is no return because of the road, or at least a part of it, being closed to traffic, and the intangible is that loss occasioned the traveling public in the use of detour roads throughout the winter from which there is no relief. This latter loss is classified for convenience as intangible, and yet it is as much a reality as if a toll were levied against each user of the detour road.

From the constructor's viewpoint "carry over" work means costlier operation and a handicap in the opening of the following construction season. To paraphrase Shakespeare: "Late awards take from the constructor that which enricheth not the political subdivision and makes him poor indeed." i. e. The full utilization of his costly equipment and organization and a fair return on the capital invested. If contracts for public work, whether state, county or municipality, were awarded in the months of November, December, January and February, the constructor would profit by having a full season ahead of him and the public would likewise profit by getting a completed project on schedule time.

It has been said in an effort to justify late awards that they create keener competition and consequently lower prices. The weakness of this position is at once apparent; it requires no refutation. Volume—supply and demand—not season affects the competitive conditions and volume can be as definitely determined in November as in the following May. The construction season is short enough at best. There is no justification for shortening it even a day. Early awards mean a full season ahead, the full utilization of equipment and organization and

completed work in time specified. Need more be said to justify the winter letting of contracts as sound economy?

ONE CAUSE FOR PRESENT LOW BIDDING

By A. E. Horst, Secy.-Treas., Henry W. Horst Company, Rock Island, Illinois

(Paper read at the 1926 meeting of Illinois Association of Highway and Municipal Contractors.)

In the "Valve World" (a Crane publication) some months ago Business was described as follows:

"Business is the term applied to the efforts of human beings throughout the world to exchange with one another the various fruits of their labor. It is essential to make this exchange in order that we may supply ourselves with food and clothing and shelter, that is, that we may continue to live. The immediate purpose of business is to supply our needs. The secondary purpose of business is that we may increase our wealth in order that we may enjoy the fruits of our labor through the development of culture and of our spiritual natures."

Business, then should give us wealth; and wealth, properly and wisely used, makes it easier for us to pursue our quest for happiness, which is the goal for all our planning and striving.

Today our particular business happens to be that of constructing permanent highways. From this business then, we that are actively engaged in it, should expect to derive the benefits above described. It is almost the universal custom where highway contracts are to be let, that this work must be secured in the open market on competitive bidding. Because of the large program of road construction that has been started within the past comparatively few years many firms have entered this field as possible contractors. Many of them have had very little, if any, experience in any sort of construction.

Permanent construction of highways, a few years ago, was a new line of endeavor, and it was necessary that a great deal of experimental work be done before definite, intelligent and economical construction of roads was developed. Equipment manufacturers were endeavoring to build such equipment as would help construct these roads for the least cost. It was necessary, however, for the contractor also to experiment largely with his own money to assist in perfecting this comparatively untried equipment.

Most of you will remember in the early years of highway work two-bag batch mixers were the standard. These mixers have now developed so that as a rule the six-bag batches seem to be the most economical. Many of you will remember the types and various kinds of untried equipment that were on exhibition at the Road Show some six or eight years ago, which at that time we all thought would be the solution of the machinery that should be used in the construction of roads. Compare the equipment for road building that was shown at the road show eight years ago with what is being exhibited there now. All of this to show that road construction during the past ten years was largely an experimental process, and the contractor had to keep very accurate records as to the performance or non-performance of this equipment. Contractors have put much of their money into this experimental stage of road construction.

In the speaker's judgment, in order to determine the reason for present low bidding among contractors, it is necessary for the purpose of discussion, that the field of contractors be divided into two classes. For this purpose, then, we will call Class 1 contractors those who have had at least two to three years' experience in highway contracting, and Class 2 contractors those who had less experience in the road game.

The greatest cause for present low bidding among Class 1 contractors (those with more than two years' experience) is, in the speaker's judgment, that these contractors do not keep intelligent cost records of their performances and constantly reflect these cost records in their bids. I like to assume that a contractor has enough brains not to want to lose money on any work that he undertakes to do. I, however, sometimes feel that the contractor is a good deal like a very sick patient for whom the doctor has prescribed medicine that happens to have a very bad taste. The patient proceeds, against his own better judgment, to refuse to take the medicine that has been prescribed and trusts to luck that he may get well without it. This is somewhat similar to the fact that, though a contractor's cost records show he should bid $2.64 per sq. yd. for slab, without cement, he cuts his bid ten, twenty or even thirty per cent and trusts to luck that somehow or other he may come out "right side up". He may also imagine that he must have a job in order to pay his overhead. It is much easier to pay a comparatively small

amount of overhead than to secure a contract and pay a much greater amount of money in loss on that contract.

This type of contractor is not willing to add a proper contingency for bad weather conditions. Those contractors who happened to have contracts in this state during the past year and who will analyze their costs intelligently, I believe will find that the weather has had a great deal to do with the delays and exceptionally high unit costs that have obtained in their work this year, and certainly should take these costs into consideration when building up bids on work of this nature in this State in the future.

The reason for low bidding among Class 2 contractors (those with less than two years' experience, and there seem to be many more of these than of Class 1) is that they do not recognize the value of the equipment that must be charged off in doing a given amount of road work. Such equipment as shovels, mixers, rollers, trucks, subgraders, finishing machines, forms, burlap, tractors, pumps, pipe line, etc.

An experience in our own organization is given. We became interested in the road game in 1919. We had back of us 26 years of experience in building construction and felt that we knew something about construction costs, and thought we also knew something about what the proper depreciation on construction equipment was. Before the first contracts were finished we owned 56 trucks and expected that these trucks would have a normal life of three years, and depreciated them in accordance with this plan. After two years of operation we discovered to our amazement that we were spending so much on these trucks in upkeep, repairs, etc., that it was necessary to dispose of the trucks forthwith. Had we not kept close cost records we would have suffered even more severely.

Our experience in the first year and a half on road construction, even with twenty-six years of building construction behind us was an exceedingly costly experience, and I am satisfied that had we not kept accurate and intelligent cost records and used these in building up our bids in securing new work, instead of trying to bid without these cost records, we might not have been here today as road contractors with all debts paid. And these records for a year and a half on thirteen miles of work did not cost us over $6,000.00. Accurate and intelligent cost records will always be worth the price if you will only use them after they are once secured.

Some unethical bonding company agents also help to interest would-be contractors in securing a job at any price in order that they may secure the benefit of the bond premium that might be theirs if contract is awarded.

A contractor should always remember that he is entitled to a fair margin of profit for his work after all other expenses have been paid, and that it is a great deal better for him to lose a job than it is to get a job and lose money on that job.

Among contractors of less than two years' experience are very often superintendents or foremen of reliable organizations who branch off in business for themselves without knowing the complete business of the organization that they have worked for. In other words, a superintendent working for a firm does not secure the entire picture of the job he happens to be running. He may figure that the cost of laying slab for a particular day is reflected in the labor cost on that day, plus the material entering into the operation for that one day, adding a small amount for plant and general expense, and knowing what the bid price is, the difference, in his judgment, is an enormous profit. He does not take into account the loss that develops on the job during rainy days, the cost of set-up, the shrinkage in materials in the mixed concrete, the wastage of materials, the overruns to be absorbed, the cost of carrying overhead during seasons when no progress is made, investment in plant, and credit involved to carry on the project, obsolescence of equipment, cost in figurig new work, and many other items of expense that an experienced contractor himself hardly realizes until the end of the year is at hand and the books close in the "red".

One of the things that is going to help in a large measure to prevent acceptance of ridiculously low bids is the continued effort to broadcast and secure the use of the standard questionnaires on which our friend, Mr. S. M. Williams of the Autocar Sales & Service Co., has spent much of his time and effort—all as a matter of personal service to the contractor.

For your information, the questionnaires have now been approved by the American Association of State Highway Officials, and adopted by at least 60 per cent of the state highway departments: by the National Surety Association, and adopted by a number of the large com-

panies; by the National Association of Credit Men, for use of their home and affiliated organizations throughout the country; by the American Bankers' Association, through their clearing house section, and 3,500 copies are being distributed to the banks throughout the country, with letters from the president of the clearing house section calling attention to the importance of the forms, and urging their use by the banks in the determining of credit for the contractor.

I am of the opinion that if the contractors, regardless of their experience, would make a real effort to get accurate and intelligent costs of doing business in the highway game and intelligently bid the costs as reflected in actual performances plus a fair margin of profit and contingency, the chief causes for low bidding would be removed.

GASOLINE TAX REFUNDS PERTAINING TO ROAD CONTRACTORS

By A. N. Bobbitt, Gasoline Tax Collector, Auditor of State's Office, State House, Indianapolis, Ind.

(Paper read at 1926 meeting of Indiana Highway Constructors, Inc.)

The gasoline tax law became effective in Indiana June 1, 1923. Up to that time only a few states in the Union had a gasoline tax; now forty-four states have a tax ranging from one cent to five cents per gallon.

In order that you may know what the Gasoline Tax Department is doing, I desire to give you a brief statement of the amount of tax collected and amount refunded, together with the number of refund claims paid.

We collected during the fiscal year ending Sept. 30, 1924, $4,741,620.31; for the year ending Sept. 30, 1925, $6,792,481.72; for the year ending Sept. 30, 1926, $8,867,947.59. We paid during the fiscal year ending Sept. 30, 1924—9,093 refund claims, totaling $79,753.53; during the year ending Sept. 30, 1925—15,407 totaling $159,407.21; and for the fiscal year ending Sept. 30, 1926, we paid 19,694 claims totaling $226,646.05, an increase of $146,892.52 over the first year, and an increase of 116 per cent in the number of claims paid. The average amount of these claims was $11.51. The entire cost of operation in this department, including salaries and all other expenses, for the last fiscal year was $11,300 05, or approximately one-eighth of one per cent of the total collections.

Many of the states having gasoline tax laws make no refunds. Tennessee, Pennsylvania and Kentucky are among this class. Some of the states like Nebraska make refunds only to farmers, and the laws provide that the gasoline must be used exclusively for agricultural purposes and none of it shall be used upon the public highways. Other states, such as Minnesota, Wisconsin, Kansas, Ohio and Indiana, refund tax on gasoline used for practically every purpose except for propelling motor vehicles upon the public highways. The laws of the states just mentioned are patterned after the Indiana law, and the tax in these states, as well as in Indiana, is a users' tax and not a sales or a privilege tax.

Indiana Tax as Affects the Road Contractor

I shall not attempt here to discuss the merits or demerits of the refund section of the Indiana law but rather to give you the requirements necessary to carry out the provisions of the law as written and interpreted by the attorney general. It is vitally important that you know how to file your refund claim properly so that you may receive your check promptly without any delay caused by returning your claim for correction or writing you for additional information.

Section 5 of the Indiana law provides that: "Any person who shall buy or use any gasoline for the purpose of operating or propelling stationary gas engines, tractors used for agricultural purposes, motor boats, airplanes or aircraft, or who shall purchase or use any gasoline for cleaning or dyeing or for any other commercial use except for propelling motor vehicles operated in whole or in part upon any of the public highways of the state, shall be reimbursed and repaid the amount of such license fee paid by him upon presenting to the Audtior of State a statement, accompanied by the original invoices showing such purchases, which statement shall set forth the total amount of such gasoline so purchased and used by such consumer, other than for propelling motor vehicles operated or intended to be operated in whole or in part upon any of the public highways of this State, and the Auditor of State shall, upon the presentation of such statement and such invoices, cause to be repaid to such consumer from the fund created by the license fees collected on the use of gasoline, as herein provided, the amount of the license fees paid by such consumer on gasoline used for purposes other than

propelling motor vehicles as hereinbefore provided. All applications for refunds or reimbursement as provided for in this section shall be filed with the Auditor of State within ninety days after the date on which such gasoline shall have been purchased, as shown by the invoice. Any person, firm, or corporation who shall make any false statement in connection with an application for the refund of any money or license fees, as herein provided, or who shall collect or cause to be repaid to him or to any person any such fees without being entitled to the same under the provisions of this section, shall be deemed guilty of a misdemeanor, and, upon conviction thereof, shall be punished by a fine of not to exceed one thousand dollars ($1,000.00)."

The first refund made to road contractors, on gasoline used in trucks, was in April, 1925. This question was presented to the attorney general by the State Auditor and the following opinion was rendered: "Section 1 of the act of March 9, 1923 (Acts 1923 p. 532), provides: 'That a license fee of two cents per gallon * * * is hereby imposed on the use of all gasoline used in this State for any purpose whatsoever.' And Section 5 provides that: 'Any person who shall buy or use any gasoline for the purpose of operating or propelling stationary gas engines * * *', etc.

"Under these provisions, I think where a contractor uses tractors in the construction of a road over a new way which has never been a public highway but which will become one only when construction is completed and does not operate his tractor on a public highway is entitled to be reimbursed and repaid the amount of such license fees paid by him.

"Where tractors are used in grading and pulling stumps in constructing a road running parallel with the old road but not in the old road bed, except where the new road crosses the old, I think its owner is entitled to be reimbursed; and also it is my opinion that a contractor is entitled to be reimbursed on account of fees paid for gasoline used in trucks to haul gravel from a gravel pit across a field to his work were such trucks are not at any time operated over or upon a public highway in transporting such gravel. Section 5 of the act provides for refunding the license fees paid for using gasoline in stationary engines, etc., 'or for any other commercial use except for propelling motor vehicles operated in whole or in part upon any of the public highways of the state,' which shows that the General Assembly intended that license fees should be refunded in all cases where such gasoline is not used to propel a car on a public highway. Of course, if such contractors operate their trucks or tractors on the public highway in going to and returning from their work, they will not be entitled to be reimbursed."

There are a number of provisions which must be complied with in order to secure a refund.

First: All applications for refund must be filed in the Auditor of State's office within ninety days from the date of purchase of gasoline as shown by the date of the invoice. This does not mean that claims may be mailed within the ninety-day period but means that such claims must be actually received in the office within that period. Do not include invoices in your claims when you are sure that such invoices will be more than ninety days old when they reach the office. The law is plain on this provision and we have no discretion in the matter.

Second: Send original invoices or original driver's delivery tickets, properly signed by the driver, in support of your claim. Do not send duplicate or any other form of invoice or delivery ticket except the original. The law presumes that persons desiring to avail themselves of the refund privilege shall preserve the original invoices, and it makes no provision for the payment of refunds upon any other evidence except the original invoice. When you include duplicate or other copies of invoices in your claim, the result is that we are compelled to return your application for the original invoices, and the payment of your refund will be delayed until the matter is adjusted.

Third: Never allow the date to be changed or an invoice to be changed or mutilated in any way, either by the tank wagon driver or any other person. If the driver accidentally puts the incorrect date on a ticket, do not allow him to erase it or change the date by "working it over"; make the driver give you a new ticket. Every invoice is carefully checked and examined, and if any have been mutilated, by the dates having been erased and rewritten or changed in any other manner, the claim is held up until we have secured a verification of the dates and invoices from the oil company. This, of course, occasions considerable delay in the payment of the claim.

Fourth: All delivery tickets must be signed by the driver and must show that the tax has been paid. This can be done

by including the tax in the price per gallon or showing it as a separate item. Frequently we receive invoices or tickets in support of a refund claim which merely show the number of gallons purchased. They do not show that the tax has been paid nor the price of the gasoline. Such invoices are incomplete and cannot be accepted for refund. See to it that your invoices are properly filled out and that all delivery tickets are signed by the driver. In case it is a credit purchase, the driver will not sign the receipt but he must sign his name some place on the ticket. It may be done in the following way or some similar manner: "Delivered by John Jones, Driver."

Fifth: All claims must be sworn to before a notary public or some officer having authority to administer oaths generally. Many claims are returned each month because the notary failed to give the date of the expiration of his commission or failed to affix his seal. In Indiana an affidavit is not complete without both of these requirements. Before mailing your claim examine it and see whether or not these things have been done. A little precaution here might save you a week's delay in the payment of your claim.

Sixth: All applications must be made in the name that appears on the invoices accompanying the application or a separate statement submitted with the claim setting out the reason for the discrepancy in names and showing the relation of one to the other.

Seventh: Persons signing affidavits for a company or partnership must designate their official capacity which authorizes them to make the affidavit, as for example, "The Union Construction Company, by John Jones, Treasurer," or "Jones Bros., by John Jones, Partner." Receipt for warrant on the back of the claim must be signed in the same manner. No warrants will be mailed by the Auditor of State unless they have been receipted for, as the law requires that he have a signed receipt for every warrant issued. The fact that you receipt for a warrant before you receive it does not estop you from securing a duplicate warrant should the original be lost.

Eighth: State specifically how gasoline is used. It is not sufficient merely to say that gasoline was used in road construction, or in construction machinery. We are unable to tell from this statement whether or not any of the gasoline was used on the public highways, and consequently when your claim is sent to us in that manner we are compelled to write you for more detailed information. Each claim should show the particular kind of machinery in which the gasoline was used; as, concrete mixers, industrial railway, road roller, etc. If the gasoline is used in trucks or tractors, you must state in each claim that such trucks or tractors were used in the construction of a road, which was closed to public travel or had not yet been accepted by the State Highway Commission or Board of Commissioners, and that such trucks traveled exclusively upon the road under construction and did not, on any part of the haul, travel upon or over a public highway which was not under construction. If your trucks travel any part of the haul over a public highway not under construction or are driven to town night and morning, then you are disqualified and are not entitled to refund on any of the gasoline used in such trucks. Trucks must be left on the job and used there exclusively. This information should be given with every claim. Each application is a separate and distinct order, and the evidence supporting the claim must be filed with it as authority for its payment.

Ninth: Always give the correct address to which warrant is to be sent. We have a number of warrants and claims in our files now and are unable to locate the owners because of incorrect and incomplete addresses.

I have given you the few simple requirements for securing refund of gasoline tax and if they are followed in detail you will have no trouble in securing your refunds promptly.

LARGEST AUTOMATIC HYDRO-ELECTRIC STATION

The largest single-unit automatic hydro-electric generating station in this country, and probably the world, is being erected on the Elwah River, 11 miles from Port Angeles, Washington, by the Northwestern Power & Light Company. This station, to be known as the Glines Canyon power house, will furnish power for the operation of the Washington Pulp & Paper Company's plant at Port Angeles. It will probably go into operation early in 1927.

A single arch dam is being constructed approximately 190 ft. high, forming a reservoir which will impound about 40,000 acre-feet, the draw-down from about half of which will be used in gen-

erating electricity. The power house will be approximately 800 ft. downstream from the dam and on the western bank of the river at the mouth of a gorge. The water will be conducted from the dam to the power house through a tunnel 575 ft. in length.

The generating equipment will consist of a 17,500-horsepower, vertical shaft, Francis turbine furnished by the Pelton Water Wheel Company, driving a 13,333-kv-a., alternating current, 6600-volt, 3-phase, 60-cycle, 225-r. p. m., 90 per cent power factor, vertical generator with direct connection exciter. This generator and all the other electrical equipment will be of General Electric manufacture, including three 4500-kv-a., outdoor type transformers and necessary switching equipment.

The automatic equipment will control and protect both the main unit and a 62.5-kv-a. auxiliary water wheel and motor driven oil pump unit. By means of selector supervisory equipment the operator at the Elwah station, seven miles distant, will give starting and stopping indications to the automatic control equipment which, in turn, will perform all the necessary operations for starting, stopping and protecting the main unit and applying field to the generator. The unit having been started, the operator at Elwah will adjust, by means of the supervisory control, the voltage and speed of the unit and synchronize it with the Elwah station.

The supervisory control will also give the operator at Elwah supervision over the load assumed by the generator at Glines Canyon and will indicate the position of the water wheel gates. The main generator will be equipped with a voltage regulator which will control the voltage after the unit has been connected to the system.

The auxiliary unit will consist of a 62.5-kv-a., 220-volt, 60-cycle, 3-phase, synchronous machine with direct-connected exciter, an oil pump and a Pelton water wheel. When the main unit is shut down the synchronous machine will act as a generator, and will furnish power for station lights and auxiliaries, being driven by the water wheel which will also maintain oil pressure. When the main unit is started up the synchronous machine will be connected to the main generator and, running as a motor, will furnish oil pressure, the governor on the auxiliary wheel automatically closing the wheel gates as the motor assumes the load. An emergency motor-driven oil pump will also be provided, starting up automatically when the oil pressure falls below a safe operating value.

The Glines Canyon power development is being designed and constructed by Thebo, Starr & Anderton, Inc., of San Francisco.

OHIO'S HIGHWAY CROSSES

G. F. Schlesinger, Ohio Director of Highways and Public Works, has received an inquiry concerning the erection of white wooden crosses to mark the points of fatal automobile accidents on the highways from F. G. Bailey of Surrey, England. Mr. Bailey desires information concerning the use of white crosses so that he can prepare articles on the same for several of the illustrated publications of England.

This inquiry indicates that the fame of the white crosses erected along the highways of Ohio has penetrated beyond the borders of this country and across the ocean to Great Britian.

A total of 1,800 white crosses have been erected by the Department at the scenes of fatal motoring accidents.

The following table shows the percentages of fatal accidents as indicated by these crosses at various typical locations as compiled from the records of the Department:

Railroad crossing	30 per cent
Turns and curves	18 per cent
Hills	6 per cent
Road intersection	7 per cent
Straight sections of road	33 per cent
Bridges	6 per cent
Total	100 per cent

While there is no actual statistical proof that these crosses have decreased the number of fatal motor accidents since their erection the Department is firmly convinced that such is the case. The favorable comment that has been received from motorists of Ohio and other states as well as various organizations and publications proves that the crosses have created an impression on the minds of the traveling public. The idea, of course, is not to let the motorist forget that possible injury or death lurks anywhere along the road for him if he drives carelessly or without consideration of the rights of others.

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DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF ALL PUBLIC WORKS

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—Scrapers, Power
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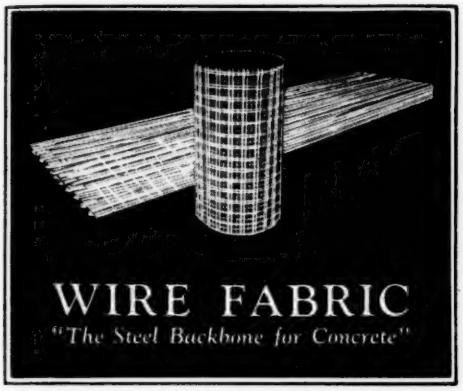
—Skimmer, Scoop
—Steam Shovels
—Stone Elevators
—Stone Screens
—Stone Spreaders
—Surface Heaters
—Tampers, Road
—Tires
—Tractors
—Trailers
—Turntables
—Unloaders, Car
—Wagon Loader
—Wheeled Scrapers
—Wire Mesh



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Wire Fabric provides Steel in its strongest form; gives positive mechanical bond and exact spacing of members.

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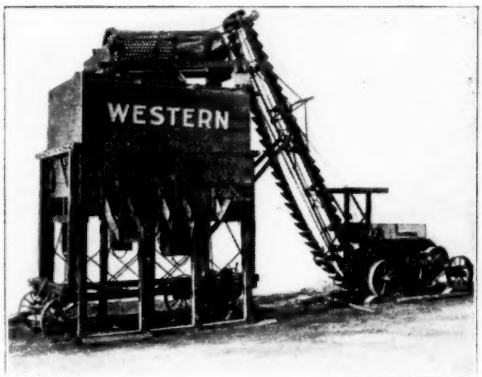
SAN FRANCISCO LOS ANGELES PORTLAND SEATTLE



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Unlike those in all other jaw crushers, which are only actually crushing 50 per cent of the time, the jaws in the **Western Aurora Crusher** are never idle. While the top half opens to grasp new stone, the bottom half closes, and vice versa. Yet there is no dead center.

This feature is alone enough to account for increased production, and lessened operating costs and wear and tear; but there are others almost equally important.

Catalog 44-H tells the whole story. Shall we send you a copy?

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Chicago

VITRIFIED Salt Glazed CLAY
Sanitary Sewer Pipe

M&CE12—Gray

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Harris Air Pump Co.

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Truscon Steel Co.

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The Barrett Co.
Kentucky Rock Asphalt Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Asphalt Paving Co., The

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The Barrett Co.
Bitoslag Paving Co.
Standard Oil Co. (Indiana)
The Texas Co.
Warren Bros. Co.

Asphalt Floors.
The Barrett Co.
The Texas Co.
Warren Bros. Co.

Asphalt Machinery.
Chausse Oil Burner Co.
Cummer & Son Co., The F. D.

Asphalt Plants.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
Littleford Brothers.
Warren Bros. Co.

Asphalt Railroad Plants
Cummer & Son Co., The F. D.
Warren Bros. Co.

Asphalt Tools.
Chausse Oil Burner Co.
Littleford Brothers.
Warren Bros. Co.

Asphalt Tool Wagons.
Chausse Oil Burner Co.
Littleford Brothers.

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Kissel Motor Car Co.
International Motor Co.
Pierce-Arrow Motor Car Co.

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Ford Motor Co.

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Austin Machinery Corporation.
Pawling & Harnischfeger.

Bar Cutters and Benders.
Koehring Co.

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Truscon Steel Co.

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Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Bros. Co.

Bituulithic Pavements.
Warren Bros. Co.

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Blasting Powder.
E. I. du Pont de Nemours & Co., Inc.

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Littleford Brothers.

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Kalamazoo Fdy. & Machine Co.

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Brick-Testing Machinery.
Tinius Olsen Testing Mach. Co.

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National Paving Brick Mfrs. Assn.

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Pawling & Harnischfeger.

Buckets, Dumping
Littleford Brothers.
Pawling & Harnischfeger

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Sauerman Bros.

Cableway Excavators.
Sauerman Bros.

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Cast Iron Pipe.
U. S. Cast Iron Pipe & Fdy. Co.

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Indiana Gunite & Const. Co.

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Flood & Co., Walter H.
Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory.
Van Trump, Isaac.

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Tinius Olsen Testing Mach. Co.

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American District Steam Co.

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Flood & Co., Walter H.
Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory.
Van Trump, Isaac.

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Truscon Steel Co.

Chimneys, Steel.
Littleford Brothers.

Chloride of Lime.
Pennsylvania Salt Mfg. Co.

Clay Pipe, Vitrified.
Clay Products Assn.

Clay Products.
Clay Products Assn.

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Concrete Mixers.
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Koehring Co.
Smith Co., T. L., The

Concrete, Reinforcement.
American Steel & Wire Co.
Truscon Steel Co.

Conduits.
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Carey Co., Philip, The.
Rosing, Inc., Astrid S.
Truscon Steel Co.

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Stewart, W. H.

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Artingstall, Wm.
Brossman, Chas.
Burd & Giffels.
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Druar & Milinowski.
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Howard, J. W.
Hunt Co., Robert W.
Indianapolis Paving Laboratory
Jones, Sam L.
Kirchoffer, W. G.
Kirschbraun, Lester.
Luten, Daniel B.
Potter, Alexander.
Van Trump, Isaac.
Wells, James P.

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Sullivan, Long & Hagerty.
Warren Bros. Co.

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Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.
Smith Co., T. L., The

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Austin-Western Road Machinery Co.

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Portable Machinery Co., Inc.
Webster Mfg. Co.

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Austin Machinery Corporation.
Heltzel Steel Form & Iron Co.
Pawling & Harnischfeger.

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The Barrett Co.
Republic Creosoting Co.

Creosoted Wood Block.
(Factory Floors, Bridge Floors)
Republic Creosoting Co.

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Good Roads Machinery Co., Inc.

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Cannelton Pipe Co.
Dee Clay Mfg. Co., Wm. H.

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Newport Culvert Co.
Truscon Steel Co.

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Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Curb Bar.
Truscon Steel Co.

Water Works Equipment Service

If in the market for any of the following water works equipment, so indicate by check marks, mail this page to ***Municipal and County Engineering,*** 702 Wulsin Building, Indianapolis, and price quotations and descriptive literature will be forwarded to you.

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—Air Lift Pumps
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—Backfillers
—Brass Goods
—Chimneys
—Chloride of Lime
—Chlorinators
—Coal Handling Machinery
—Concrete Hoisting Equipment
—Concrete Tanks
—Condensers
—Conduit Rods
—Cranes, Locomotive
—Cranes, Traveling
—Curb Boxes
—Curb Cocks
—Derricks, Pipe Laying
—Derricks, Steel Portable
—Drinking Fountains
—Dry Feed Chemical Apparatus
—Engines, High Duty
—Engines, Gas
—Engines, Oil
—Engines, Pumping
—Explosives
—Fence, Iron
—Fittings, Wrought
—Filter Equipment
—Gates, Sluice
—Gauges, Recording
—Gauges, Steam
—Gauges, Water
—Goose Necks
—Hydrants, Fire
—Indicator Posts
—Lead
—Leadite
—Lead Furnaces
—Lead Wool
—Leak Indicators
—Liquid Chlorine
—Lime
—Meter Boxes
—Meter Couplings
—Meter Testers
—Motor Trucks
—Motors, Electric
—Oil, Lubricating
—Pipe, Cast Iron
—Pipe Cutters
—Pipe, Lead-Lined
—Pipe, Steel
—Pipe, Wrought Iron
—Pipe, Wooden
—Pitometers
—Pumps, Air Lift
—Pumps, Boiler Feed
—Pumps, Centrifugal
—Pumps, Deep Well
—Pumps, Steam
—Pumps, Trench
—Pumps, Turbine
—Pumping Engines
—Service Boxes
—Soda Ash
—Specials, Cast Iron
—Standpipes
—Steam Boilers
—Steel, Reinforcing
—Sulphate of Alumina
—Tamping Machines
—Tanks, Elevated
—Tapping Machines
—Trench Braces
—Trenching Machines
—Valve Boxes
—Valve Inserters
—Valves, Gates
—Valves, Pressure Regulating
—Water Main Cleaners
—Water Meters
—Water Softening Plants
—Welding Apparatus
—Well Drills
—Well Screens
—Well Strainers

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Keystone Driller Co.

Drag-Line Excavators.
Austin Machinery Corporation.

Scrapers.
Austin-Western Road Machinery Co.

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Dee Clay Mfg. Co., W. E.
Rosing, Inc., Astrid S.

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Cummer & Son, The F. D.

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Austin-Western Road Machinery Co.

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Standard Oil Co. (Indiana)
The Texas Co.

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Truscon Steel Co.

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Westinghouse Electric & Mfg. Co.

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Austin-Western Road Machinery Co.

Excavating Machinery.
Austin Machinery Corp.
Pawling & Harnischfeger.
Sauerman Bros.
Smith Co., T. L., The

Expansion Joint Compound.
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Carey Co., Philip, The
Pioneer Asphalt Co.
Truscon Steel Co.

Explosives.
E. I. du Pont de Nemours & Co., Inc.

Fillers (Paving Joint).
The Barrett Co.
Carey Co., Philip, The
Pioneer Asphalt Co.
The Texas Co.

Fire Brick.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Flue Liners.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

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Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms, Road.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

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U. S. Cast Iron Pipe & Fdy. Co.

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Coldwell-Wilcox Co.

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Austin-Western Road Machinery Co.

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Granite Paving Block Mfrs. Assn. of the U. S., Inc.

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Indiana Gunite & Const. Co.

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American District Steam Co.

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Littleford Bros.

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Pawling & Harnischfeger.

Hoists, Electric.
Mead-Morrison Mfg. Co.
Pawling & Harnischfeger.

Hoists, Steam.
C. H. & E. Mfg. Co.
Mead-Morrison Mfg. Co.

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Austin Machinery Corp.

Inlets (Sewer).
Dee Co., Wm. E.
Madison Foundry Co.

Insulating Material.
The Barrett Co.
Pioneer Asphalt Co.

Joint Fillers (Paving).
The Barrett Co.
Carey Co., Philip, The.
The Texas Company.

Kettles (Portable).
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Littleford Brothers.

Manhole Covers.
Madison Foundry Co.
Dee Co., Wm. E.

Mastic.
The Barrett Co.
Pioneer Asphalt Co.

Meter Boxes.
McNutt Meter Box Co.

Mixers, Asphalt.
Austin Machinery Corporation.
Cummer & Sons Co., The F. D.

Mixers, Concrete.
Austin Machinery Corp.
Koehring Co.
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Motor Fire Apparatus.
Duplex Truck Co.
Federal Motor Truck Co.
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Motor Trucks.
Duplex Truck Co.
Federal Motor Truck Co.
Ford Motor Co.
International Motor Co.
Kissel Motor Car Co.
Pierce-Arrow Motor Car Co.

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Austin Machinery Corporation.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
The Gramm-Bernstein Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
Pierce-Arrow Motor Car Co.

Municipal Castings.
Dee Co., Wm. E.
Madison Foundry.

Packing.
Pioneer Asphalt Co.

Paints (Asphalt).
Barrett Co., The
Pioneer Asphalt Co.

Paving Blocks (Creosoted).
The Barrett Co.
Republic Creosoting Co.

Paving Brick.
Murpysboro Paving Brick Co.
National Paving Brick Mfrs. Assn.

Paving Contractors.
Warren Bros. Co.

Paving Joint Compound.
The Barrett Co.
Carey Co., Philip, The
Pioneer Asphalt Co.
The Texas Company.

Paving Joint Filler.
The Barrett Co.
Carey Co., Philip, The.
Pioneer Asphalt Co.
The Texas Company.

Paving Machines.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
East Iron & Machine Co., The
Warren Bros. Co.

Paving Plants (Asphalt).
Austin Machinery Corporation.
Cummer & Son., The F. D.
East Iron & Machine Co., The
Good Roads Machinery Co., Inc.
Smith Co., T. L., The
Warren Bros. Co.

Pipe Cutters.
W. W. Strickler & Bros.

Pipe Dip and Coatings.
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Pioneer Asphalt Co.
The Texas Co.

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Pitch Filler.
The Barrett Co.
Warren Bros. Co.

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Austin Machinery Corporation.
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Littleford Brothers.
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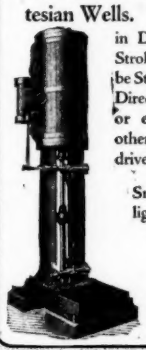

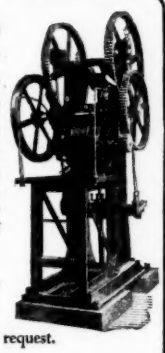

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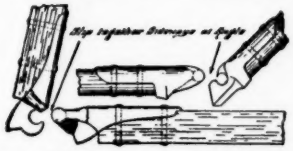

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Austin-Western Road Machinery Co., The
Buffalo-Springfield Roller Co.
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Keystone Driller Co.
Littleford Brothers.
Warren Bros. Co.

Road Planer.
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The Texas Co.

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Buffalo-Springfield Roller Co.

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Kentucky Rock Asphalt Co.

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Pioneer Asphalt Co.
Warren Bros. Co.

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Littleford Brothers.

Scarifiers.
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Scrapers, Drag Line.
Pawling & Harnischfeger.
Sauerman Bros.

Scrapers, Graders, Plows, Etc.
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Sauerman Bros.

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Kalamazoo Fdry. & Mach. Co.
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Truscon Steel Co.

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Rosing, Inc., Astrid S.

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The Barrett Co.

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Dallmann Machine & Mfg. Co.
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Truscon Steel Co.

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Austin-Western Road Machinery Co., The

Stone Elevators.
Austin-Western Road Machinery Co., The

Stone Spreaders.
Austin-Western Road Machinery Co., The
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Austin-Western Road Machinery Co., The
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Lufkin Rule Co., The

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Austin-Western Road Machinery Co., The

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Tarvia.
The Barrett Co.

Testing Chemists.
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Walter H. Flood.
Howard, J. W.
Kirschbraun, Lester.
Van Trump, Isaac.

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Tractors.
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Holt Mfg. Co., Inc.

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Warford Corp.

Trench Braces.
Kalamazoo Fdry. & Mach. Co.

Trench Machinery.
Austin Machinery Corporation.
Kalamazoo Fdry. & Machine Co.
Pawling & Harnischfeger.

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The Hug Co.

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Cannelton Sewer Pipe Co.

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Warren Bros. Co.

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National Water Main Cleaning Co.
Stewart, W. H.

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Carey Co., Philip.
Pioneer Asphalt Co.
Truscon Steel Co.

Water Purification.
Direct Oxidation Process Corp.
Pennsylvania Salt Mfg. Co.

Water Softener.
The Refinite Co.

Water Works Supplies and Equipment.
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American Steel & Wire Co.

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Truscon Steel Co.

Wire-Cut Lug Brick.
Murphysboro Paving Brick Co.

Wood Block (Creosoted).
Barrett Co., The
Republic Creosoting Co.

Wood Preservatives.
Barrett Co., The
Republic Creosoting Co.

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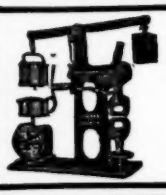

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